LOS ALAMOS NATIONAL LABORATORY

ANNUAL REPORT TO THE REGENTS UNIVERSITY OF CALIFORNIA

S. S. HECKER • DIRECTOR

December 1996

A U.S. DEPARTMENT OF ENERGY LABORATORY

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Cover photo: PUB90112028

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Los Alamos
NATIONAL LABORATORY

PROFILE

Established in 1943 as Project Y of the Manhattan Engineer District, Los Alamos National Laboratory's original mission was to develop the world's first atomic bomb. Today, Los Alamos is a multidisciplinary, multiprogram laboratory. The University of California has managed the Laboratory since its beginnings in 1943. An important consequence of this management is the Laboratory's commitment to maintaining the tradition of free inquiry and debate that is essential to any scientific undertaking.

The Laboratory's original mission to design, develop, and test nuclear weapons has broadened and evolved as technologies, U.S. priorities, and the world community have changed. Today, we support our core mission, *reducing the global nuclear danger,* with the technical competencies developed for our national security and other programs. These competencies in turn allow us to contribute to civilian and conventional defense needs where our ability to perform large-scale, interdisciplinary research and development gives us a competitive advantage. We use partnerships with industry and universities to increase the effectiveness of our own work and to help us learn from others. In all our programs, we continue to maintain an intellectual environment that is open to new ideas. In addition, we are committed to ensuring that all our activities are designed to protect employees, the public, and the environment.

DIRECTOR'S STATEMENT

During the past year the U.S. Government took significant steps toward defining a post–cold war national security strategy. These steps have, in turn, allowed the Department of Energy (DOE) to move forward with its plans for the future of the nuclear weapons program. These actions have all served to strengthen the Laboratory's central mission of *reducing the global nuclear danger*.


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Siegfried S. Hecker, Director

Although not apparent at the time, the end of World War II in 1945 marked a sharp discontinuity in world affairs. The invention of gunpowder and the rise of nation states led to casualties from war of about 6 million for each of the seventeenth and eighteenth centuries. The increasing mechanization of warfare led to nearly 20 million casualties in the nineteenth century. This trend continued in the early twentieth century, with over 80 million dying in wars in just the first half of this century. Since then the ever-escalating death toll from war has dropped precipitously to less than 25 million during the past fifty years. It is difficult to escape the conclusion that the development and use of nuclear weapons to end World War II fundamentally changed the relationship among nations. While regional wars continue to claim all too many lives, great conflagrations among the major powers of the world have been contained.

Yet those fifty years also witnessed an unprecedented arms race between the United States and the Soviet Union. The superpowers invested great amounts of their national treasure in creating arsenals of thousands of nuclear warheads, most of them with many times the destructive power of those that ended World War II. The investment, coupled with a huge standing army and an inefficient economy, eventually bankrupted the Soviet Union and it broke apart, with consequences still to be discovered. The "peace" during the last half of the twentieth century was an uneasy one.

During 1996 the United States took action on two major treaties directed at reducing the global nuclear danger. In January, the Strategic Arms Reduction Treaty (START) II was ratified by the Senate. Although the treaty is not yet ratified by the Duma, the United States and Russia are on a clear path to the reduction of nuclear strategic systems. Following this success, the leaders of the five declared nuclear weapons states signed the Comprehensive Test Ban Treaty (CTBT) in New York in September. Formal ratification of this treaty is problematic because some nations are resisting key provisions. However, its acceptance by the nuclear weapons states and the vast majority of the community of nations is a significant development. These events come on the heels of the indefinite extension by the United Nations of the Nonproliferation Treaty (NPT) last year.

The CTBT represents the end of new nuclear weapons design activity by the nuclear powers and a strong inhibition to the acquisition of sophisticated nuclear weapons capability by non-nuclear-weapons states. The NPT will help limit the spread of nuclear weapons and nuclear materials capabilities and help safeguard weapons-capable materials from diversion to clandestine weapons programs. Together with START I and II, these agreements form the cornerstones for a new, stable era in nuclear weapons.

President Clinton has clearly reaffirmed the critical role of nuclear weapons to deter war and keep the peace:

> The United States must and will retain strategic nuclear forces sufficient to deter any future hostile foreign leadership with access to strategic nuclear forces from acting against our vital interests and to convince it that seeking a nuclear advantage would be futile.

Moreover, in his call for negotiation of a zero-yield comprehensive test ban, he stated in August 1995,

> As a central part of this decision, I am establishing concrete, specific safeguards that define the conditions under which the United States will enter into a comprehensive test ban. These safeguards will strengthen our commitments in the areas of intelligence, monitoring and verification, stockpile stewardship, maintenance of our nuclear laboratories, and test readiness.
>
> They also specify the circumstances under which I would be prepared, in consultation with Congress, to exercise our supreme national interest rights under a comprehensive test ban to conduct necessary testing if the safety or reliability of our nuclear deterrent could no longer be certified.
>
> As a part of this arrangement I am today directing the establishment of a new annual reporting and certification requirement that will ensure that our nuclear weapons remain safe and reliable under a comprehensive test ban.

The DOE's weapons laboratories are charged with keeping those weapons deemed critical for national security safe and reliable—without nuclear testing and without replacing them with new models. This is a difficult task and we cannot guarantee success. It is our job to provide the technical framework for the building of a new world with many fewer nuclear weapons. For the time being, we must provide the strategic nuclear forces necessary to deter any hostile foreign leadership from acting against our national interests. In the absence of nuclear testing, this is an incredibly difficult task. No other large-scale, complex technical system has been maintained without exercising it in some way. Yet we must make sure that our confidence in the performance of the nation's nuclear stockpile is highly visible and robust, even in the absence of explosive testing of the weapons. Our plan to accomplish this daunting task is science-based stockpile stewardship.

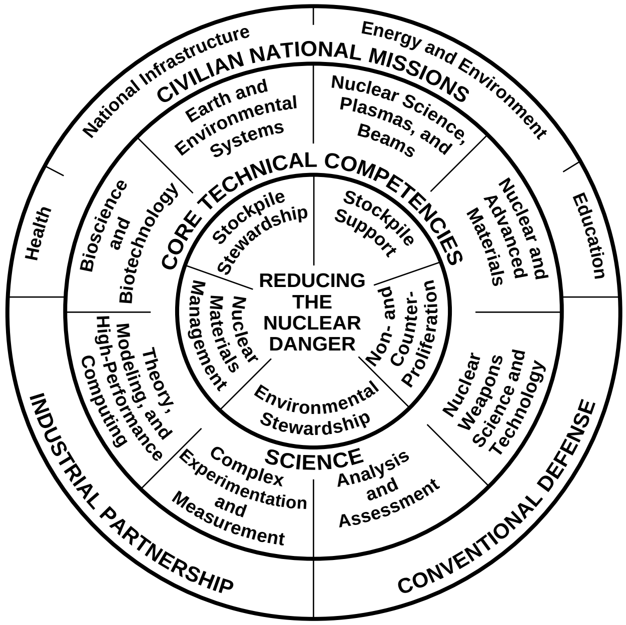
Science-based stockpile stewardship will require enhanced surveillance so that we can understand the changes that will inevitably occur in the materials in the weapons. It will require that we understand the fundamental science involved so that we can assess the effects those changes may have on weapons performance. It also will require that we do this with sufficient predictive capability so that we can respond in a timely way, with remanufactured parts that will preserve the integrity of the stockpile. The Laboratory has an important role in each of these areas integrating our research and development (R&D) capabilities with an expanded manufacturing capability. As an example, our expertise in plutonium technology in particular is essential to the success of the program. We have already assumed responsibility for surveillance of pits, and we have always been deeply involved in plutonium materials science. The DOE's plans call for us to take on a manufacturing role for pits as well. I believe that the close integration of these tasks will strengthen the program and lead to real cost savings for the nation.

The integration of the Laboratory's role in the nuclear weapons program and the quality of the work we do comes back to me in a very direct way. As Laboratory director, I must annually certify that the weapons for which we have responsibility—the majority of the stockpile—are safe and reliable. I must have confidence that the science we bring to bear on our weapons responsibilities is of the highest quality. Confidence in our scientific understanding of weapons physics will ensure confidence in the performance of the nation's nuclear stockpile.

Confidence in our science in turn requires that the Laboratory participate in a substantial way in the greater national scientific enterprise. It is not sufficient for Los Alamos to be a great weapons laboratory; we must be a scientific laboratory of the first rank, collaborating where appropriate with industry and universities to match our minds with the best the world has to offer. To do this we must not only collaborate with many participants across a broad spectrum of scientific fields, we must also ensure the continued revitalization of our staff through recruitment of young talent and the development and use of the most advanced scientific tools available. It is no coincidence that Los Alamos is embedded within a major research university. Association with the University of California not only assists us in recruiting the best talent available, it reminds us that science and excellence provide the basic foundation for success in our mission. We can take the long-term view of a government laboratory, yet we have the talent that allows us to move rapidly into emerging areas of science and technology.

In addition to providing for the continued safety, security, and effectiveness of the weapons that remain, including an adequate supply of tritium for the remaining warheads, we must also help ensure that the proliferation of weapons of mass destruction, still a very real threat, can be detected and, if necessary, countered. In particular, we must work with our former adversaries in Russia to ensure that the weapons, the specialized knowledge, and the materials which both nations worked so hard to produce do not fall into the wrong hands. We must ensure that the long-term disposition of nuclear materials is consistent with environmental preservation and nonproliferation goals, and we must clean up the legacy of the fifty-year development history of the nuclear weapons complex. These tasks form the core of our mission—*reducing the global nuclear danger*.

Our mission is supported by eight core competencies: nuclear science, plasmas, and beams; nuclear and advanced materials; nuclear weapons science and technology; analysis and assessment; complex experimentation and measurements; theory, modeling, and high-performance computing; bioscience and biotechnology; and earth and environmental systems. These core competencies, in turn, provide the basis for our selective participation in civilian national missions, conventional defense R&D, and industrial partnerships. Work in these areas serves other important national needs while providing critical support to our core mission by strengthening and maintaining our core competencies. Thus, *reducing the global nuclear danger* is an effective shorthand for our mission, but it requires understanding the competencies needed



Los Alamos National Laboratory's central mission—reducing the global nuclear danger—requires the maintenance of core technical competencies that also contribute to civilian national needs.

to fulfill that mission and how they will be supported.

In the new world that the end of the cold war has brought about, the Laboratory is in a very good position. Our overall budget position for FY 1997 is strong, having stabilized in real terms after several years of volatility. In particular, the budget for our stockpile stewardship and management activities is up slightly in real-dollar terms, a tribute to the strength of our mission and the vigor of our science and technology. We have a clear and compelling national mission and have taken the sometimes painful steps to increase our value to our ultimate customer, the American people. We are not without problems, but on balance we are in a very strong position to embark on the difficult task of science-based stockpile stewardship and to serve national needs in other defense and civilian areas.

The Laboratory has been fortunate, particularly in the present climate, to experience a renaissance of civilian R&D capability, primarily through investments at the Los Alamos Neutron Science Center (LANSCE) but also through Laboratory Directed Research and Development (LDRD) and University of California Directed Research and Development (UCDRD) funding. We are well on our way to a significant upgrade in LANSCE capabilities, and we look forward to its future role as the premier site in the nation for neutron scattering. We have recently recast our LDRD program to more clearly support the defense mission of the Laboratory, as well as the vitality of defense-related scientific areas. The growth of UCDRD funding, provided by the management fee paid by DOE to the University, has enabled a number of outstanding projects performed in collaboration with campus researchers strengthening our ties to the University. Several of these projects are described in this report.

In the near future, we will have to try to sustain our activities within a discretionary federal budget that is projected to shrink dramatically. These projected cuts will have a significant effect on the Laboratory and the rest of the nation's R&D enterprise. Universities, along with federal laboratories, will have to become more efficient and make more effective use of federal R&D funds. With private sector R&D both shrinking in absolute terms and focused increasingly on short-term developments, the future of the nation's sources of innovation and creativity is truly at risk.

As we look to the future, we are fortunate to have a compelling national mission. What we do for the nation in national defense and civilian science and technology fills a real need and has the support of our customers. The Laboratory must continue to stress the quality of the science and technology we bring to bear on these problems and continue to attract and keep a talented staff that can hold their own with the best in the world. However, to be fully successful, we must also demonstrate world-class operations. Safety must truly come first and be an integral part of what we do, but we must also demonstrate cost-effective performance to the American taxpayer. I look forward to leading the Laboratory toward this future with confidence that we can meet every challenge.

National Security Needs

"The United States must and will retain strategic nuclear forces sufficient to deter any future hostile foreign leadership with access to strategic nuclear forces from acting against our vital interests and to convince it that seeking a nuclear advantage would be futile.... I consider the maintenance of a safe and reliable nuclear stockpile to be a supreme national interest of the United States.... We can meet the challenge of maintaining our nuclear weapons deterrent under a Comprehensive Test Ban Treaty through a Science-Based Stockpile Stewardship program without nuclear testing."

President Bill Clinton, August 11, 1995

Science-Based Stockpile Stewardship and Management

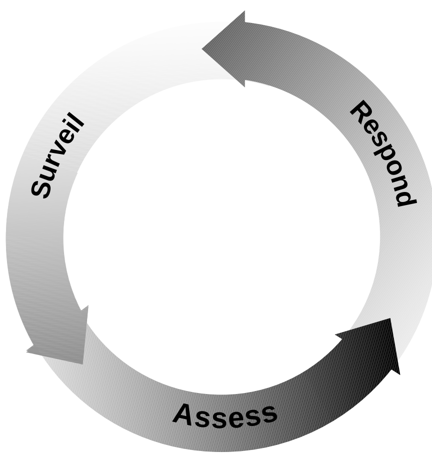
For the past fifty years, the nuclear weapons stockpile was maintained through a strategy of surveillance, nuclear and non-nuclear testing, and an active program of replacing old warheads with new designs. Now, our objectives include ensuring the safety and reliability of a smaller stockpile and enhancing nonproliferation efforts while observing a comprehensive test ban. These combined objectives have given rise to a new science-based stockpile stewardship and management paradigm to meet the new conditions.

As the stockpile ages and as we move further from immediate test experience, we must develop new capabilities to enhance existing core stewardship capabilities. The Laboratory is committed to meeting the near-term scientific and technical demands of stockpile stewardship and management and maintaining our long-term, capability-based deterrent posture. The technical challenges associated with the program require that we continue to attract and retain first-class scientists and engineers, develop new scientific and engineering capabilities, and develop a deeper understanding of weapons science and engineering.

Our weapons scientists and engineers must be able to predict with confidence whether a change observed in an aging stockpile weapon will affect its reliability or safety. At the same time, we must be able to certify safety and performance to meet the system's military requirements. We will gain the needed confidence through improved computational capabilities for modeling and simulation, through investments in specific new experimental capabilities to benchmark and validate computational models, and by expanding fundamental knowledge of materials science at the atomic level.

The Laboratory's stockpile stewardship and management activities underpin the technical basis for all U.S. nuclear weapons in the stockpile. Through its core program, the Laboratory performs the fundamental research, the development of physical models, the integration of computer simulation codes, the experimental validation, and the systems engineering that are necessary for the certification of stockpile systems. In addition, the Laboratory sets all technical specifications for surveillance and manufacturing operations and for maintenance activities conducted by the Department of Defense (DoD). The core program relies on three interconnected areas of activity to provide the basis for continued certification and reliability assurance:

- surveillance to allow us to examine and diagnose aging phenomena in stockpile weapons and materials;
- assessment of the physical observations through detailed calculations and experiments for the evaluation of the safety and performance of each weapon; and
- development of appropriate responses based on those expert assessments, responses that may include modifications to or remanufacture of warhead components or changes to operational procedures.



Surveillance, assessment, and response are the key elements of science-based stockpile stewardship and management.

Surveillance

In a cooperative venture between the remaining nuclear weapons production plants and the laboratories, DOE is restructuring its surveillance activities to meet the needs of science-based stockpile stewardship and management. The Laboratory's surveillance assignments include all plutonium pits (the fission cores of nuclear weapons), detonators, valves from gas boosting systems, and radioisotope-fueled thermoelectric generators that are part of some weapons systems.

In pit surveillance, a comprehensive inspection and materials analysis formerly performed at the Rocky Flats Plant, we exceeded our annual goal of evaluating nineteen pits and introduced new scientific assessment methods in anticipation of the need for long-range predictive capability. Our detonator evaluation and manufacturing role matured as well. For certain stockpile evaluation tests, Los Alamos delivers detonator simulators meeting the same rigorous quality standards as those required of actual stockpile components. We also established some quality-assurance capabilities to meet rigorous war reserve quality-assurance requirements and began the test firing of surveillance detonators.

We collaborate with the Westinghouse Savannah River Plant in the surveillance of tritium components and in the processing and recycling of tritium. We also pressed ahead with our responsibility for loading tritium in neutron tube targets for a Sandia National Laboratories neutron generator from Lockheed-Martin. Our improved loading process reduced by 90 percent the amount of radioactive waste normally generated.

Even as we generate new information on the properties and behavior of materials in nuclear warheads, we must preserve earlier information and integrate it with the new. Archiving the previously recorded nuclear weapons data in an easily retrievable form ensures a wealth of information for assessing stockpile weapons systems and improving models and codes necessary for a better understanding of the details of weapons science.

Assessment

Assessment activities are at the core of the Laboratory's involvement in science-based stockpile stewardship and management. To understand the performance basis of nuclear weapons, we must understand all the physics and materials science involved in their operation. Reaching this understanding requires an extensive suite of experimental and theoretical capabilities and their careful integration.

Accelerated Strategic Computing Initiative

We will depend on high-performance computing and computational simulations more than any other technology to continue validating and certifying the safety, reliability, and performance of the nuclear package in the absence of nuclear testing. For decades, computing was an extremely effective, critical tool in the design and development of new warheads, but its utility depended heavily on nuclear tests to supply specific data for calibrating the physics models in our codes and for proof-testing a final design. We must now rely on predictive simulations alone, without new nuclear tests, to assess the effects of aging and engineering modifications. The Accelerated Strategic Computing Initiative was begun in 1996 to develop a series of new, high-fidelity computer simulation capabilities to predict a warhead's safety and nuclear performance and the fundamental effects of aging and replacement of its nuclear components.

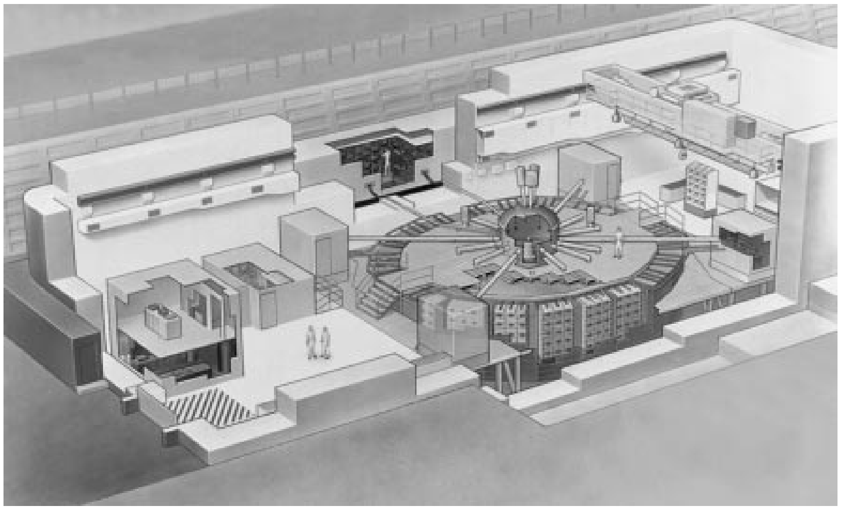
These capabilities have both a hardware and a software component. We teamed with Silicon Graphics, Inc., to develop computers and their supporting software that are 10,000 times more powerful than the largest machines available today. Los Alamos pioneered the use of parallel computers in weapons assessments; we now lead in pursuing a new approach to parallel computer design that involves clustering hundreds to thousands of relatively low-cost, high-performance, commercial multiprocessors for the development of a 3-teraflops computer system.

Code development for these new machines will depend on our strong science base in such disciplines as weapons physics, materials science, and numerical applied mathematics. We are developing software for the Accelerated Strategic Computing Initiative aimed at reusing existing codes and machine-to-machine portability. This year we have worked with weapons code teams to develop simulation capabilities with some important user-interface features. Most of the design phase is complete, and prototypes are ready for a variety of simulated test problems.

Hydrodynamic Testing

Hydrodynamic tests—high-explosives-driven experiments for studying primary implosions—constitute our most important aboveground, nonnuclear testing capability. They address the most immediate issues related to stockpile reliability—the functionality and safety of the primary stage. The principal diagnostic tool for hydrodynamic testing is high-resolution, dynamic radiography. When complete, the Los Alamos Dual-Axis Radiographic Hydrotest (DARHT) Facility will provide major improvements needed for stockpile evaluation and assessment. Construction on DARHT resumed in 1996; the experiments with its first beam axis are to be performed in 1999.

Subcritical experiments at the Nevada Test Site are another important means of addressing these stockpile reliability concerns. These experiments will involve nuclear materials such as plutonium, but they will not produce self-sustaining nuclear reactions and are, therefore, consistent with a zero-yield comprehensive test ban treaty. The subcritical experiments will complement dynamic experiments that will be conducted at other Laboratory facilities such as DARHT.



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Atlas facility for high-energy-density experiments.

Neutron Radiography, Neutron Scattering, and Materials Science

The Los Alamos Neutron Science Center (LANSCE) provides a valuable resource for numerous scientific experiments in materials science research. Through neutron scattering and radiography, scientists can address a wide variety of materials issues, including aspects of high-explosives burn, shocks, aging-related phenomena, and a material's equation of state. LANSCE capabilities also allow the measurement of nuclear cross sections. LANSCE is discussed at length in a later section of this report.

High-Energy-Density Physics Regimes

The science-based approach to stockpile stewardship requires a detailed understanding of the physics at the ultrahigh energy densities found in a nuclear device. There are two approaches to addressing high-energy-density problems—pulsed-electrical-power sources and high-energy lasers. Pulsed-power approaches include electrical discharge systems and high-explosives-driven pulsed-power systems. High-energy-laser experiments are conducted in coordination with the national Inertial Confinement Fusion (ICF) Program.

Atlas will be a new pulsed-power test facility with the capability to create pressures in targets that are almost an order of magnitude larger than those possible with the present facility. The new facility will enable scientists to perform larger-scale (centimeter-sized) experiments at temperatures high enough to ionize the material. The target material will reach the pressure, volume, and energy density necessary to verify weapons-related computer calculations. DOE began funding Atlas in FY 1996. The commissioning of the facility is scheduled for late FY 1999.

Los Alamos plays a major role in the national ICF program, placing primary emphasis on target physics. We resolve critical issues associated with demonstrating the feasibility of ignition for the National Ignition Facility planned for Lawrence Livermore National Laboratory; we directly involve core weapons personnel in the measurement of basic phenomena in weapons physics. We pioneer integral calculations of indirect drive that are essential in explaining x-ray temperature and capsule symmetry in ICF experiments.

Validation of Reliability Models

One issue resulting from extending the lifetime of the nuclear stockpile is that of reliability of these complex systems. We are developing a structured, quantitative approach to the reliability of nuclear weapons systems as they age. The procedure, with the W-76 warhead as a test system, involves using expert judgment when other relevant information is unavailable or severely limited. The method has three parts: development of a logic model (a fault tree), incorporation of expert judgment, and information storage and analysis. Uncertainties are propagated through the model in order to obtain a reliability characterization of the entire system.

Direct validation of the resulting reliability characterization is not possible because adequate performance data for aging nuclear weapons systems are lacking. However, the methods can be validated by applying them to cases for which performance data are available. A partnership with the automotive industry involves the analysis of the aging of a fuel injection system and provides an opportunity to validate the methods that are developed for our defense mission.

Response

As part of its plan for the nuclear weapons program, DOE has proposed transferring some activities formerly performed at production plants to other sites in the remaining complex, including Los Alamos. Because of plant shutdowns and the unavailability of some materials currently used in nuclear weapons, the Laboratory must select replacement materials and develop advanced engineering criteria and manufacturing technologies for repair and component requalification. A plan consistent with reduced production requirements, no nuclear testing, and long-lifetime requirements for the stockpile weapons requires close integration of the research and development effort, the enhanced surveillance program, and a flexible manufacturing complex.

Laboratory-Scale Pit Manufacture

DOE plans for pit manufacturing call for the limited-scale production of up to fifty pits per year at the Los Alamos plutonium facility. In addition, we have formed a team with colleagues at Lawrence Livermore National Laboratory, the Savannah River Plant, and Pantex to plan contingencies for larger-scale pit-production capacity that could be deployed rapidly should requirements change.

Establishing the capability to build war-reserve quality pits on a laboratory scale is progressing well. The Laboratory completed the transfer of necessary Rocky Flats hardware and gauging equipment and is building a smaller, more accurate inspection gauge. We fabricated, processed, and machined a half-dozen full-scale plutonium castings in 1996. The last time such operations were conducted was in early 1992 in support of underground testing. We also demonstrated the first laser weld of plutonium. The Laboratory remains committed to producing pits for the stockpile. We plan to demonstrate this commitment by manufacturing a war reserve pit for the W88 warhead (Trident II) in FY 1998. We demonstrated a variety of other manufacturing technologies for reducing waste generation and operator exposure to radiation. One of our innovations, a component-cleaning process, eliminates the need for chlorinated hydrocarbon and fluorocarbon fluids by substituting supercritical carbon dioxide, which can be recycled.

Stockpile Modifications: The B61-Modification 11

The Laboratory, with DOE and the rest of the weapons complex, was assigned the testing and certification of the B61 gravity bomb, modification 11. The B61-11 will allow the retirement of the B53 bomb, which does not have some of

Field test of the B61-11 casing. The Laboratory is participating in the modification of the B61 for earth-penetrating missions to enable the retirement of an older design.

the modern safety and security features of the B61. We are using mission analyses, together with tests conducted in Alaska in February and in Tonopah during the spring and summer, to determine the environment that the preexisting nuclear explosive of the bomb must withstand. We are conducting a series of component survivability tests to these levels. Existing B61 parts will be used wherever possible, including the entire nuclear explosive portion. Delivery of the first field modification kit is expected in December 1996, nine months ahead of the original schedule.

Aerial view of LANSCE. The extensive facilities serve various projects in stockpile stewardship and management and in civilian research and development.

Los Alamos Neutron Science Center

LANSCE is a powerful spallation neutron source that includes the Manuel Lujan Jr. Neutron Scattering Center, the Weapons Neutron Research facility, the world's most powerful proton linear accelerator, and a proton storage ring. LANSCE is a major component of the Laboratory's strategic plan to become the center in the United States for the development and use of spallation neutron sources. In 1996 LANSCE completed its transition to a DOE Office of Defense Programs facility, with a primary mission to carry out research in support of stockpile stewardship and management. A second, synergistic mission, funded by the DOE Office of Energy Research, is to serve as a national neutron science user facility.

LANSCE and the neutron laboratory initiative are vital to the Laboratory in a number of ways. First, LANSCE will provide data fundamental to surveillance and assessment the nation's nuclear stockpile. Second, LANSCE is the central facility for development of technology for the production of tritium, a critical stockpile requirement. Third, neutron science and technology are critical to Laboratory core competencies in advanced materials science, nuclear science, particle beam technology, and nuclear weapons science—all of which are needed to fulfill the Laboratory's role in stockpile stewardship and management. Finally, LANSCE provides opportunities in basic research, which help to establish it as both a magnet to attract new talent to Los Alamos and a bridge to the weapons program for that talent.

LANSCE Facility Improvements

To meet national needs in defense, industrial, and basic research applications more effectively, LANSCE is improving its facilities and operations. A reliability improvement project, funded by DoD and underway since 1994, will provide more reliable and convenient operations, extend the annual run cycle to eight months, and increase the spallation target power to 80 kilowatts. Benefits of both this effort and improved operations are already apparent, with significant reliability gains in the 1995 and 1996 run cycles when compared with those of the recent past. In 1996 a high-resolution gamma-ray detector array, obtained from the Lawrence Berkeley National Laboratory, was installed at the Weapons Neutron Research facility.

LANSCE has also embarked on a program to enhance its short-pulse-spallation source (SPSS). This effort will provide LANSCE performance levels equal to or better than the best pulsed-spallation source in the world—the Isis facility in the United Kingdom. The enhancement is jointly supported by the Offices of Defense and Energy Research Programs at DOE, with Defense Programs providing accelerator upgrades to increase target power to 160 kilowatts, and Energy Research funding development of seven new instruments at the Lujan Center.

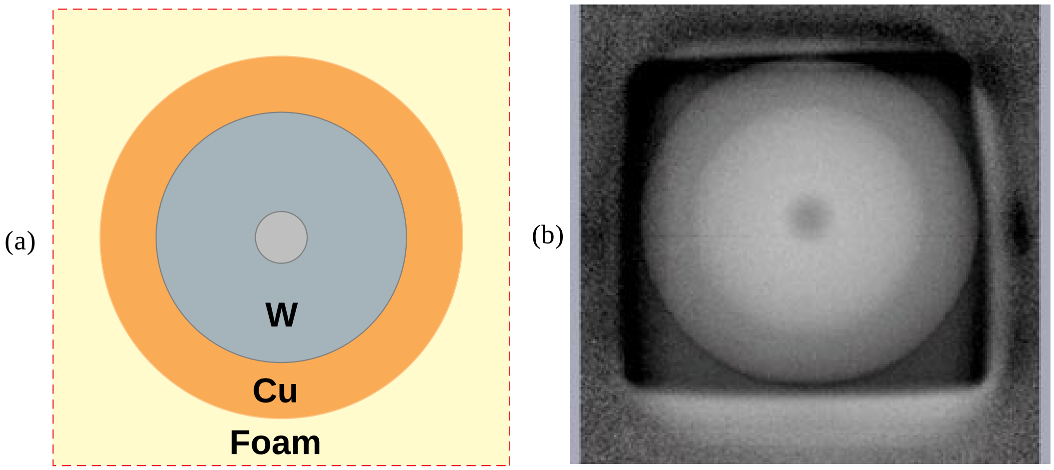
To meet long-term national needs, Los Alamos has proposed the addition of a new 1-megawatt long-pulse-spallation source (LPSS) to LANSCE. The LPSS will be constructed in an existing building at the end of the linear accelerator and will provide advanced capabilities for neutron scattering using cold neutrons, a field of research that underpins many current advanced technologies in areas such as polymers and ceramics. Complementing the existing SPSS, the LPSS will provide a cold-neutron capability which is as much as four times that of the world's best facility—the research reactor at the Institut Laue Langevin in France. Together, they will produce neutrons over a wide range of energies and provide capabilities that rival or surpass those of the world's leading facilities. The LANSCE LPSS is the Laboratory's highest-priority new research facility for the next five years and is supported by both Defense and Energy Research Programs at DOE.

Contributions to Stockpile Stewardship

Researchers use LANSCE to address a range of issues critical to long-term weapons stewardship. Neutron diffractometry, small-angle scattering, reflectometry, and inelastic scattering techniques are answering material science questions related to the aging of weapons components. LANSCE is providing a better understanding of the science that underlies models for predicting the behavior of explosively compressed plutonium, the surveillance of light materials deep inside an aging nuclear device, and the study of the performance and sensitivity of high explosives.

Los Alamos is developing static neutron radiography techniques that can provide enhanced contrast over that obtainable from x-rays, enabling inspection of the condition of low-atomic-number materials deep inside a high-atomic-number material assembly. Current work focuses on improved resolution and speed. A blind, defect-finding test on a weapon mockup will provide the ultimate test of this new technique.

Los Alamos leads in developing high-energy proton radiography for dynamic applications. Proton radiography will provide quantitative information beyond that available with x-ray-based radiography. Successful 1996 proof-of-principle experiments performed at Brookhaven National Laboratory suggest that very high energy protons may provide critical advantages over x-rays for dynamic radiography applications. We plan a series of further experiments at LANSCE to develop detector technology, modeling capability, and other expertise needed for the full hydrotest application. We also expect that dynamic proton radiography experiments on small-scale, high-explosives-driven assemblies will prove important to the study of weapons



Test object (a) imaged with 10-giga-electron-volt protons (b). The object is a foam box containing concentric spheres of copper and tungsten with a void at the center.

hydrodynamics. The study of proton radiography is now part of a trilaboratory effort directed toward a next-generation hydrotest facility.

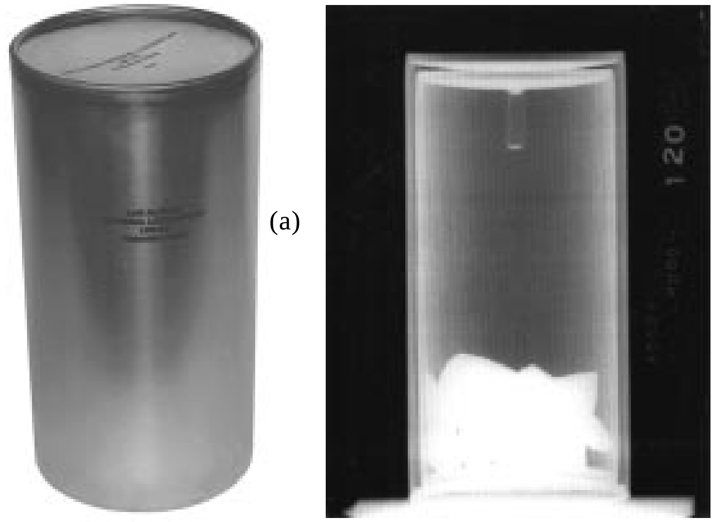
Accelerator Production of Tritium

At present, the United States has no facility able to produce tritium for nuclear weapons; DOE is recycling tritium recovered from dismantled weapons to meet stockpile needs. However, as the existing tritium stores decay, eventually a new source will become necessary. The nation is exploring options in a dual-track approach to producing tritium: a reactor source and an accelerator source. The proposal for accelerator production of tritium (APT) calls for a high-power proton accelerator to produce a very high flux of neutrons by spallation, which would in turn produce tritium through a reaction with a helium-3 target. APT provides significant environmental and safety advantages compared with reactor production, because it uses no fissile material and has the flexibility to meet changing tritium requirements should stockpile needs change in the future. DOE will choose between the options early in FY 1999.

Los Alamos, long a world leader in accelerator research and development, is leading the multilaboratory development effort. In early September, DOE announced the selection of Burns and Roe Enterprises, Inc., as the prime contractor which, with its partner General Atomics, will work with Los Alamos and the other laboratories. Initially, most APT work will occur at Los Alamos, including most conceptual design activities, engineering development, and technology demonstrations. A low-energy, full-current, demonstration accelerator is being built to provide design confirmation, operational experience, and reliability assessment of components. The proton injector developed for this demonstration has already met the beam requirements for APT. In addition, technology demonstrations are underway, including materials irradiation and corrosion studies at LANSCE, providing materials and engineering data critical for the final design of the plant.

APT requires an immense amount of nuclear cross section information which is used in radiation transport codes to calculate the interaction of the accelerated beam of protons with the target and blanket materials. The results from these calculations are combined with experimental measurements to produce high-quality nuclear data libraries. One of the most important benefits from such analyses is the accurate prediction of the number of neutrons per proton and, consequently, the amount of tritium produced.

During the final stages of design, a transition will occur as construction begins at the Savannah River site in 1999 if DOE chooses to proceed with the accelerator option. Los Alamos will retain design authority for the accelerator, target/blanket, and tritium extraction facilities and will provide technical oversight of APT throughout the life of the project.



(a) (b)

Welded double can of plutonium (a), available for International Atomic Energy Agency inspection and safe storage. The plutonium seen in the x-ray image (b) is in an unclassified form.

Nuclear Materials Management

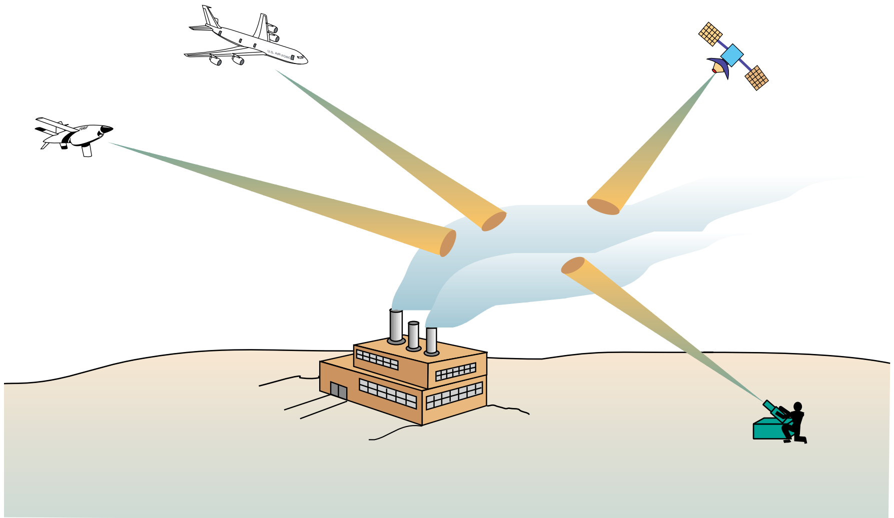
Los Alamos has had a pivotal role in dealing with the enormous quantities of nuclear and other materials from the dismantlement of U.S. weapons and with legacy material remaining at former production plants. Los Alamos plays a leading role in helping DOE address a Defense Nuclear Facility Safety Board recommendation that involves the stabilizing of plutonium-contaminated materials until decisions are made concerning plutonium disposition.

At the Rocky Flats Plant last December, we provided assistance while a ton of plutonium oxide was placed under International Atomic Energy Agency safeguards. During the year we provided technical support in material stabilization to the new management contractor at Rocky Flats, including input to project plans, peer review of proposals, and development of specific processes. We also trained thirty Rocky Flats operations staff members. With DOE assistance, we are reaching out to academic institutions in this research and development program to broaden our scientific base and to recruit new scientists and engineers for this challenging work.

In an extensive series of workshops, we are exploring how arms control, nonproliferation, nuclear weapons, nuclear science, and nuclear power technology might evolve and interact with nuclear material policies and options. The study includes the modeling of future global energy requirements and fissile material inventories and work on concepts for new nuclear fuel cycles that are “nonfertile“; that is, the cycles will conserve plutonium without breeding more plutonium, offering a proliferation-resistant approach to nuclear power. These activities constitute the Nuclear Vision Project, which seeks to identify and clarify issues related to the long-term future of nuclear energy and its relation to weapons, arms control, and proliferation.

Nonproliferation and Counterproliferation

Proliferation of weapons of mass destruction and the means to deliver them remain major national security issues despite the end of the cold war. Events such as the Aum Shinrikyo cult’s subway attack using chemical weapons last year in Tokyo highlight the vulnerability of U.S. civilians and interests to these threats. The proliferation of weapons of mass destruction is the most urgent and direct threat to



Investigators will use laser-based systems to monitor potential proliferant activities.

national security. The threat to U.S. civilians and interests is real, and the political, social, economic, and psychological impacts are potentially devastating. We perform research in a wide variety of technologies that have broad application in both national security and dual-use areas. We develop and apply Laboratory science and technology to deter, detect, and respond to proliferation and to ensure U.S. and global security.

In May we played a leading role in establishing a national agenda for reducing the nuclear, biological, and chemical (NBC) threat. With Harvard University, we co-hosted a national-level conference of senior administration officials, congressional leaders, academics, and laboratory experts who reviewed the NBC threat and in bipartisan cooperation developed a coherent U.S. response that was enacted into legislation. The legislation and subsequent funding broadened the DOE role to include mitigating biological and chemical weapons threats and countering the smuggling of nuclear weapons and materials. We expect to play a major technical role in supporting federal agencies' needs, from NBC prevention, through detection and interdiction, to both crisis and consequence management.

Reducing the NBC threat requires timely warning and advanced detection technology. Adequate intelligence and monitoring in turn require leading-edge science and technology applied across a broad spectrum of applications. We are developing in-field assessment, protection, and countermeasure technologies to respond to and mitigate the effects of NBC use, including extension of the Nuclear Emergency Search Team approach to the emerging threats. Los Alamos scientists continue the development of better capabilities for detecting and recognizing signals from clandestine nuclear explosions in the atmosphere or in space. Small, inexpensive satellites, designed by Los Alamos researchers, also serve as data-gathering tools to help scientists investigate astrophysical phenomena, Earth's ionosphere, and the physics of lightning. We continue development of an advanced light detection and ranging (LIDAR) system for detecting and characterizing effluents associated with proliferation activities. In October 1996, in partnership with the U.S. Air Force, we successfully conducted the first tests of this technology from an airborne platform.

Environmental Stewardship

Environmental Restoration

The Laboratory continues its progress in environmental restoration. We cleaned up fifty-three contaminated sites and completed seventeen decommissioning projects. We exceeded virtually all the University of California-DOE-negotiated performance measures in FY 1996. We also worked with the New Mexico Environment Department, the Environmental Protection Agency, Sandia National Laboratories, and DOE to develop general guidelines for determining cleanup levels, to clarify regulatory and administrative requirements, and to provide a standardized format and level of detail for documents necessary to the environmental restoration process.

Productivity improvements in 1996 allowed our waste management program to complete more work, including the decommissioning of the controlled air incinerator and disposal of some nondefense waste, for the same level of funding. The Laboratory also developed an aggressive plan to eliminate legacy waste from its defense activities within ten years and will be ready to ship waste to the Waste Isolation Pilot Plant in 1998.

New Environmental Cleanup Technologies

We continue to develop and implement new environmental technologies and received two R&D 100 Awards in 1996 for technologies with environmental cleanup applications. The R&D 100 Awards are given by *R&D Magazine* for the 100 best technical advances of the year. Los Alamos researchers won the awards for the transportable remote analyzer and the plasma-mechanical cleaning process described in the following paragraphs.

TRACER's main analysis unit fits in the back of a vehicle and is connected to a probe by fiber-optic cables. An operator analyzes a material—in this case soil—by holding the probe against the surface.

Transportable Remote Analyzer

Los Alamos researchers, with ICF Kaiser Inc. engineers, developed an instrument to analyze soils for metal contaminants. The Transportable Remote Analyzer for Characterization and Environmental Remediation (TRACER) can be carried into the field in a van or station wagon to perform measurements on site. A probe, which attaches to the main analytical unit, can be located up to 80 feet away from the unit, allowing access to difficult sites such as down a mining borehole. Focusing powerful laser pulses on the sample to form a series of laser sparks causes a small mass of the sample to vaporize, and the resulting atoms become excited and emit light. The analytical unit automatically identifies the composition of elements in the soil by their unique spectral fingerprints by employing a hardware/software system developed at Los Alamos specifically for the TRACER unit.

Plasma-Based Decontamination Techniques

The Laboratory, working with Beta Squared, Inc., developed a revolutionary plasma-mechanical cleaning process, PLASMAX, which allows the cleaning of silicon wafers inside plasma-processing chambers. The process has the potential to eliminate much wet processing in the semiconductor industry. By eliminating certain washing, rinsing, and drying steps, PLASMAX reduces the use and volume of hydrocarbon and fluorocarbon solvents and the total steps in the fabrication process. The process may also be useful for decontaminating fixtures and tools, greatly reducing the volume of waste that is produced in the handling of radioactive materials. The development of PLASMAX was supported in part by University of California Directed Research and Development funding.

Catalytic Treatment of Tritiated Water

The Laboratory successfully demonstrated a novel process to recover tritium from tritiated waste water. The two-stage palladium membrane reactor is the only system in the United States that is capable of recycling tritium from water without generating additional waste. Tritium can now be recovered from the large amount of tritiated water that exists in temporary storage, with the added benefit of greatly reducing the amount of tritium buried as waste. In addition to processing waste, the palladium membrane reactor has the potential for integration into tritium facilities to eliminate the generation of tritiated water altogether. We are now demonstrating treatment of actual tritiated water waste. Tritium recovery in this demonstration is essentially complete; no tritium could be detected in the process waste stream.

Conventional Defense Activities

Funding for conventional defense programs from DoD enables us to make innovative contributions to national security and, at the same time, help support competencies needed for our core mission. Numerous Laboratory-derived technologies are in development for the military services across several general technological areas.

Downsizing within DoD and the subsequent demilitarization of massive quantities of munitions have emphasized the need for high-performance explosives that are easier to dispose of, recycle, or convert to other useful products. The new explosive TNAZ has features that make it very attractive for next-generation munitions. It offers high performance and can easily be disposed of or recycled. Until now, however, TNAZ was expensive to produce and yielded a large waste stream. Los Alamos has developed a new synthesis process that increases yield efficiency from 17 to 70 percent, while simultaneously reducing the pollution burden by a factor of five. We transferred the new process to Aerojet, the industrial manufacturer of TNAZ, thereby providing DoD an important new option for next-generation munitions.

DoD is using computer codes more extensively for system development and assessment than it has in the recent past. This increase is largely driven by the need to reduce development times, minimize environmental impacts associated with testing, and enable confident decisions early in the development cycle. One prominent example is the extensive use of continuum codes to assess interceptor lethality in missile defense. Los Alamos developed a new code whose run-efficiency and robustness make it useful for conducting evaluations across a broad set of parameters. The Ballistic Missile Defense Organization has adopted the new code, SPHINX, as one of the two approved lethality codes within the missile defense program.

To detect battlefield releases of biological agents, Los Alamos is developing a miniature flow cytometer (MiniFCM) for use by the U.S. Army. The work includes the development of a lighter-weight, lower-power, smaller-volume flow cytometer replacement for the existing commercial system. Mounted with other components in a shelter on the back of a small field vehicle, the MiniFCM is only 2.4 cubic feet in volume and can detect the presence of microorganisms in a sample in 2 minutes and identify a microorganism in 15 minutes. We are developing the MiniFCM under a partnership with Bio-Rad Laboratories, which will manufacture the instrument for the Army. The team has successfully developed, tested, and delivered two units to the Army. Several immunoassays have been demonstrated for the MiniFCM and the development of an extensive set of agent-specific immunoassays is in progress. The instrument may also prove useful as an inexpensive clinical laboratory instrument for infectious-disease diagnosis.

Miniature flow cytometer for battlefield detection and identification of biological-warfare agents.

To support DoD, Los Alamos is developing a nonintrusive chemical detector that will be used for specific identification of chemical weapons agents, agent precursors, industrial chemicals, and other relevant chemicals within a variety of sealed containers. Researchers have successfully tested a prototype system on surrogate-filled 155-millimeter munitions at Dugway Proving Grounds and completed precursor-chemical characterizations.

Laboratory-to-Laboratory Interactions with the Russians

The Laboratory is working to reduce the threat of weapons of mass destruction through collaborative projects with colleagues in Russia and other states formerly in the Soviet Union, with a goal of increasing stability in three major areas: nuclear materials, weapons expertise, and weapons institutions.

In the spring of 1994, the national laboratories, with Los Alamos in the lead, suggested a laboratory-to-laboratory approach to securing nuclear weapons materials with the Russian weapons institutes. Building on a foundation of trust and cooperation established through scientific collaboration between U.S. and Russian weapons laboratories since 1992, this approach proved remarkably successful. By the end of FY 1995, rapid progress was made at a number of Russian institutes. The best of Russian and American materials protection, control, and accounting (MPC&A) technologies and methods were combined in an extensive demonstration facility that paved the way for widespread implementation throughout the Russian nuclear weapons complex.

Expansion of collaborative work with the Russians during FY 1996 dramatically improved the security of Russian nuclear materials. The collaboration included work at further nuclear weapons sites, as well as reactor fuel sites, and a program to safeguard nuclear material while being transported between nuclear facilities on rail cars. In addition, full-scale MPC&A systems were

Los Alamos works with many nuclear institutes and laboratories in Russia to improve the safeguarding of nuclear materials and technology.

installed at six more facilities across the nuclear complex. The program also added four reactors and the Novosibirsk enrichment facility. In addition, MPC&A upgrades were continued at four Russian sites that joined the program earlier.

This highly successful approach to safeguarding nuclear materials has expanded to Belarus, Latvia, Ukraine and Kazakhstan—four now-independent nations that formerly were part of the Soviet Union. In Kazakhstan, three new sites were added, and MPC&A upgrades were continued at a production facility. In Ukraine, one new site was added, and MPC&A upgrades were continued at four other sites. MPC&A upgrades were also completed at research reactors in Belarus and Latvia.

The Industrial Partnering Program, begun in 1994, continues to promote collaborations with scientists in over twenty Russian institutes on projects that will substantially interest U.S. industry. We engage Russian scientists from weapons institutes in projects leading to nonmilitary applications of their expertise. Los Alamos has more than thirty projects underway, several of which have attracted significant cost-share from U.S. industry and which complement the technical capability and interests of the Laboratory. The Los Alamos project portfolio ranges from development of parallel computing algorithms to sophisticated manufacturing-process development.

Collaborative Experiments

Magnetized target fusion, a novel approach to fusion, may have potential advantages over the more traditional approaches of magnetic and inertial confinement. Magnetized target fusion is a staged process in which a warm, dense plasma is compressed by the implosion of the vessel surrounding the plasma. The compression of the initial plasma heats the plasma to ignition conditions.

In a historic collaboration with scientists at the Sarov in Russia, several researchers at Los Alamos are studying one approach to the creation of the initial target plasma in a program called MAGO, a Russian acronym for magnetic compression. The MAGO concept, originated by Andrei Sakharov, involves a complex electrical discharge in a chamber filled with neutral gas. Past experiments were directed toward the process of plasma formation and measurement of the plasma density and temperature.

Activities during the past year concentrated on the independent problem of implosion. In an experiment researchers examined the hydrodynamic stability of a hollow, aluminum cylinder as it imploded under magnetic forces onto an internal diagnostics package. We believe that this type of implosion might be compatible with the earlier plasma formation experiments and allow for a full, magnetized-target fusion test.

Civilian National Needs

The great strength of our Laboratory is the quality of the science and technology it applies to its missions. The Laboratory's identity and international recognition rests upon its sustained performance in satisfying national needs in science and technology. Programs in civilian science and technology, supported by other DOE offices such as the Office of Energy Research, as well as work for other federal agencies in the civilian sector, help support necessary capabilities. Further, maintaining the quality of the Laboratory's work requires that our scientists be integrated into the broader scientific and technical community. We interact strongly with university researchers, and we are increasingly working in partnership with industry to help meet mission requirements.

Whether in basic research, the human genome or other bioscience programs, materials research and development, energy technologies, high-performance computing, space, or the application of Laboratory-developed technologies to commercial uses, activities in civilian research and development serve important national needs while helping to maintain the vitality of the Laboratory.

As we apply our core competencies to civilian needs, we reinforce the reputation of the Laboratory for quality science and technology. In the past year we took major steps to position the Laboratory as a major player in the national neutron science community. We are also expanding our efforts in the biosciences, particularly in structural biology with the application of neutron scattering. The following paragraphs describe these developments and highlight some of the many technical accomplishments of Laboratory researchers. They also highlight the role we play in education and our partnerships with industry.

Los Alamos Neutron Science Center

In addition to its national security role, the Los Alamos Neutron Science Center (LANSCE) serves as a national neutron science user facility. Basic research at LANSCE covers a wide range of topics in condensed-matter physics, nuclear physics, materials science, chemistry, structural biology, geology, and engineering. Much of the basic research carried out at LANSCE involves university participation, and many of the experiments serve as an integral part of the education and training of young scientists. Neutron scattering has also become increasingly important to industrial research, allowing scientists to probe the structures of materials such as polymers, catalysts, and structural composites that are essential for many modern industrial products.

LANSCE offers a range of instruments for probing the structure of materials, facilities for neutron irradiation, and spectrometers for addressing a variety of neutron-scattering issues and nuclear physics experiments. There are currently ten state-of-the-art instruments, including a unique spectrometer and a powder diffractometer with a resolution higher than that of any other instrument of its type in the

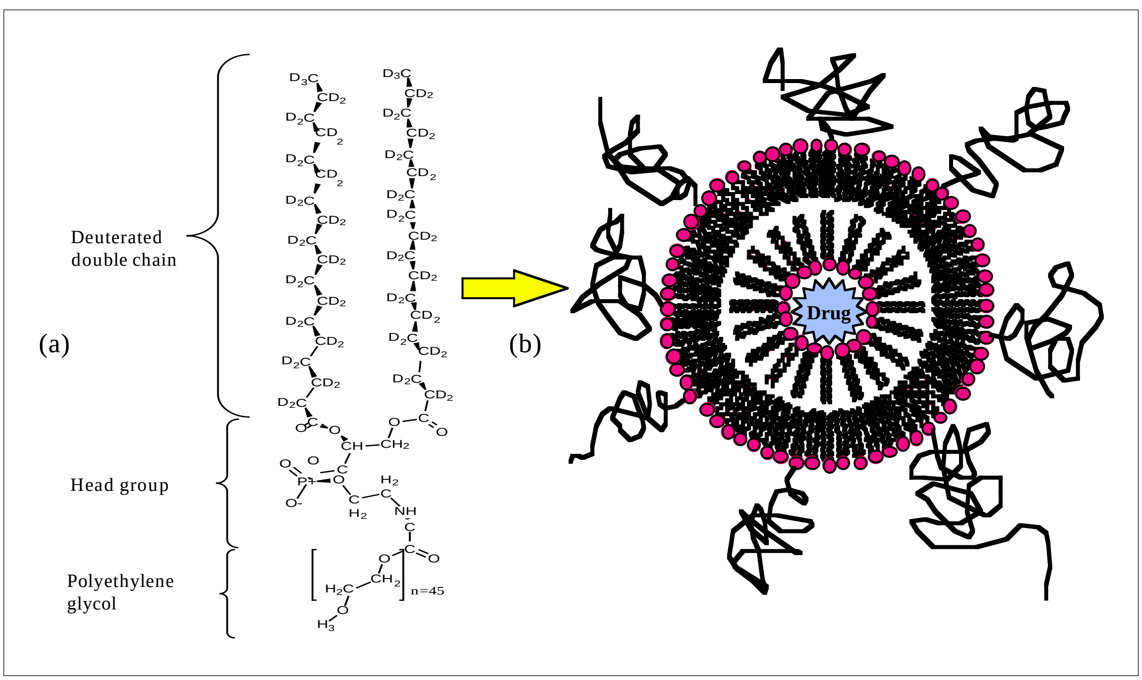
United States. As a part of its continuing commitment to LANSCE, the Office of Energy Research agreed to fund, over the next five years, the construction of an additional seven instruments at the Manuel Lujan Jr. Neutron Scattering Center. The national neutron-scattering community as a whole will participate in the selection, design, and construction of the instruments. Construction of the first instrument, a structural biology station for the study of protein crystallography, will begin in 1997. The additional neutron-scattering instruments are part of the short-pulse-spallation-source enhancement, a cooperative effort between the DOE Offices of Energy Research and Defense Programs, with Defense Programs funding accelerator improvement to increase target power to 160 kilowatts.

Committed to meeting user needs and addressing their concerns, LANSCE is in the midst of a major reliability improvement project, described previously, to enhance user satisfaction. To maintain close ties to the user community, in 1996 LANSCE created an external committee, the LANSCE Advisory Board, which will review periodically the center's operations and planning. The LANSCE User Group was also organized as a means for individual participation. The group's inaugural meeting, held at Los Alamos in August, drew over 170 participants, the majority from outside the Laboratory. In addition, to give users a single point of contact with the facility, LANSCE appointed a full-time user coordinator.

Nuclear and Accelerator Research

Neutron-Scattering Research

In a collaborative effort involving Los Alamos, the University of California at Santa Barbara, and the Risø National Laboratory of Denmark, researchers performed experiments to gain insight into the physical properties of lipid-polymer liposomes. Lipid-polymer liposome coatings play an important role in advanced oral medication delivery systems by shielding the drug from digestion and permitting it to reach the site where it is needed. Empirical experience



A model of the polyethylene glycol-lipid molecule (a) and a liposome, used for drug delivery (b), built by incorporating polyethylene glycol-lipids into its outer surface.

suggests there is an optimal thickness for the coatings, and the goal of the research is to determine that thickness. Using the time-of-flight neutron reflectometer at the Manuel Lujan Jr. Neutron Scattering Center, the researchers studied mixtures of deuterated or hydrogenated lipid compounds, as well as the same lipids modified by the attachment of polyethylene glycol. The measured reflectivity profiles provide a precise description of the water / polymer-lipid / air interface and show that the roughness of this interface increases with the polyethylene glycol concentration, indicating that the bulky polymer disrupts the order in the lipid monolayer.

Accelerator Development

The sub-picosecond accelerator is a unique accelerator facility that produces extremely short (less than 1 picosecond) electron bunches with high peak current (greater than 1 kiloampere) and high brightness. This combination of features, unduplicated elsewhere worldwide, is the result of combining two Los Alamos–developed technologies and represents a new regime of electron accelerator technology. This facility has been used for conducting bunch compression experiments and for generating exceptionally short ultraviolet radiation (down to wavelengths of 22 nanometers) by exciting a neon plasma. At present, experiments are underway to develop new diagnostics in this new ultrashort-pulse regime and to explore critical accelerator issues related to scaling the technology to a practical device. In addition, this facility can be used for studying compressed-beam physics issues that will be important for large, advanced future accelerators, such as TeV-class linear colliders and extreme-ultraviolet free-electron lasers.

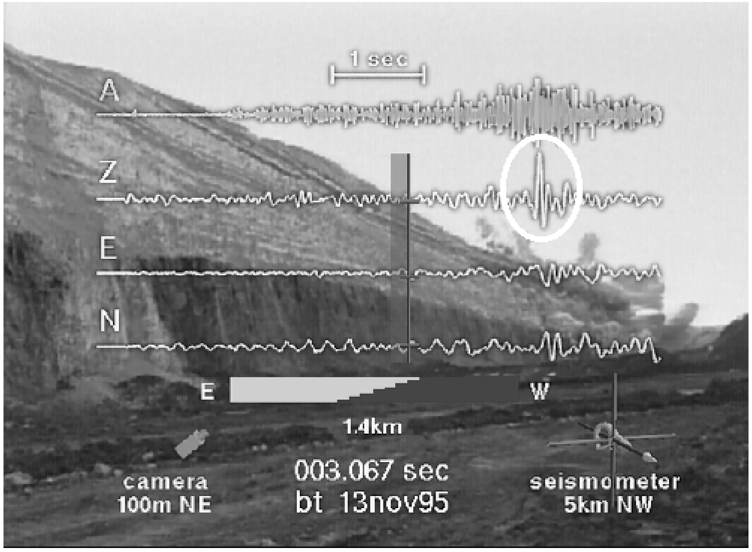
Liquid Scintillator Neutrino Detector

Collaboration at Los Alamos on the liquid scintillator neutrino detector (LSND) continues to present strong evidence for an excess of electron antineutrinos from the neutrino target at Los Alamos. Since announcing first results in early 1995, the LSND group has operated its experiment for an additional four months, providing a total of nine months of data. The data are consistent with neutrinos changing from one neutrino type to another, a process known as neutrino oscillations. For neutrino oscillations to occur, neutrinos must have mass and there must be mixing among the neutrino types. A recent publication reports twenty-two events that are consistent with muon antineutrinos that had changed (oscillated) into electron antineutrinos. The expected number of such events from background sources is only 4.6 with an uncertainty of 0.6 event, making it extremely unlikely that the observed excess is due to a statistical fluctuation. If the excess is indeed due to neutrino oscillations, the implication is that at least one neutrino has a mass greater than 0.2 electron volt. If confirmed by other experiments, massive neutrinos will have an enormous impact on our understanding of the makeup and evolution of the universe. This work is supported in part by University of California Directed Research and Development (UCDRD) funds.

Earth and Environmental Systems

Monitoring the Test Ban Treaty

One of the major obstacles confronting governments that will be monitoring the Comprehensive



Mining explosions such as this one will be detected by CTBT seismic monitoring. Trace A is an acoustic signal, Z is vertical ground motion, and E and N are directional horizontal motions. The simultaneous detonation of multiple explosions produces a seismic signal (circled) that must be discriminated from a possible nuclear explosion.

Test Ban Treaty (CTBT) is the seismicity associated with mining explosions and the opportunity such explosions present for evading the CTBT. The largest mining explosions are easily observed on the global monitoring systems and number several hundred per year.

Los Alamos researchers actively monitor mining explosions in the Powder River Basin coalfield in Wyoming using seismic, infrasonic, and video instrumentation. The close characterization and integration of signals from the basin provide the data from which to extract the explosion phenomenology of mining explosions, identify problems in the blasting methods that could lead to an erroneous identification of an illegal nuclear explosion, and develop methods to discriminate between legal mining explosions and nuclear explosions. In addition to providing strong support to the U.S. and international CTBT monitoring communities, this work provides the mining industry with data to mitigate the impact of an in-force CTBT on the mining operations.

Experimental Confirmation of the Geodynamo

Last year we described the first dynamically consistent three-dimensional numerical simulation of the geodynamo, the mechanism in Earth's core that generates and maintains the geomagnetic field. Our simulated magnetic field, which now spans over 200,000 years, has an intensity and a dipole-dominated structure that is very similar to Earth's and a westward drift of the nondipolar structures that is also similar to the drift measured on Earth. Our solid inner core rotates about 2 to 3 degrees per year faster than the mantle, a prediction we made for Earth that was subsequently confirmed by two independent seismic analyses. The radius of our solid inner core grows about 3 centimeters per century as iron in the fluid alloy above freezes onto it. A reversal of the dipole polarity occurs about 36,000 years into our simulation and takes a little more than 1000 years to complete, similar to what is seen in Earth's paleomagnetic record. This work is supported in part by UCDRD funds.

Yucca Mountain

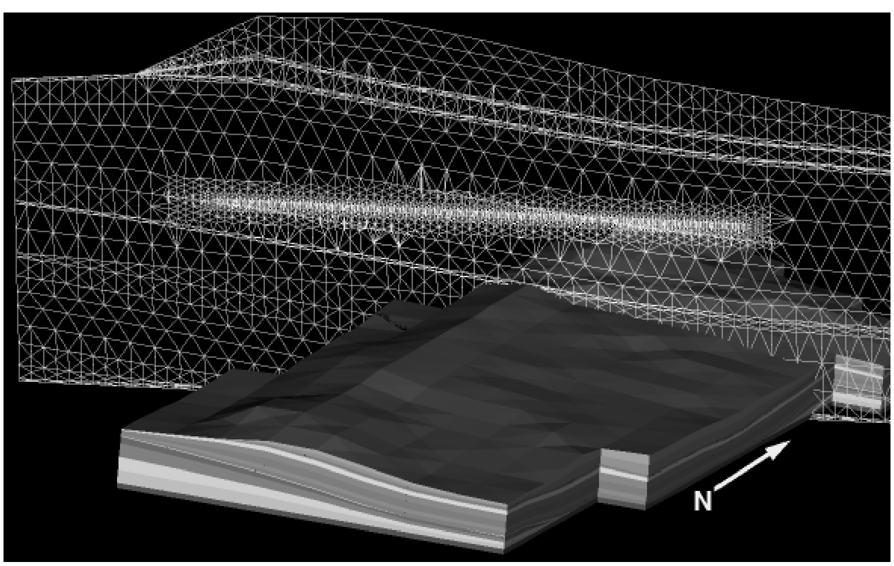
The geologic disposal project for high-level radioactive waste at Yucca Mountain, Nevada, has focused for many years on the isolation ability of the natural barrier—a massive layering of volcanic tuff units above and below a water table. Past conceptual models suggest that any migrating radionuclides would be controlled and limited by low water flux through the repository in the unsaturated zone and would be diluted if the radionuclides reached the water table, the saturated zone. Recent Los Alamos results suggest that the performance of the repository depends also on the time-varying flux of radionuclides, not just on the water flux. Other transport mechanisms, such as radionuclide sorption, diffusion, and dispersion, are enormously important for natural barrier performance because they delay the migration of radionuclides from the repository site to the accessible environment.

Los Alamos has produced the project's first three-dimensional, site-scale, unsaturated zone integrated flow and transport model. The model was also used to produce the first flow and transport model of the site-scale saturated zone coupled to the regional hydrology model. These models and simulations are of unprecedented detail and scope, incorporating data from hydrologic, mineralogic, structural, geochemical, and actinide chemistry studies. This complex integration was possible through the application of modeling techniques that were developed for the weapons program to geologic problems. The first fully coupled, multidimensional simulation of neptunium transport explored the effect of hot-waste-package emplacement and the sensitivity of neptunium transport to flow paths, sorption, diffusion, dispersion, and dilution. These simulations suggest that Yucca Mountain is a robust natural barrier.

Theory, Modeling, and High-Performance Computing

Oil Reservoir Simulation

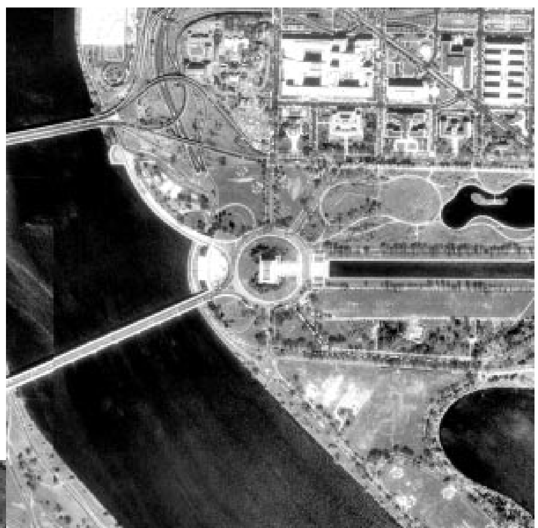
Los Alamos researchers have developed advanced reservoir simulation software, known as Falcon, which is the first production-quality oil reservoir simulator to harness the power of high-end parallel computer technology. One hundred times faster than its nearest competitors, Falcon offers high-accuracy modeling of large, economically important oil fields in their entirety. Falcon represents a paradigm shift for the oil and gas industry in predicting future revenues from their properties; the software makes feasible detailed simulations of large oil fields, which account for over half the world's oil production. Other applications offered by this advanced software include the planning of facilities at production sites, development of long-term economic strategies for oil recovery, and simulation of underground pollutant dispersion. This work, which enhanced our capabilities in parallel computing, was performed in a partnership with Amoco, Cray Research, and ERC Tigress.



Model for calculating neptunium transport from a repository in Yucca Mountain, Nevada.

Image Compression Technologies

In the past year Los Alamos researchers significantly improved software applications that compress large images and image databases. Known as the multiresolution, seamless image database (MrSID), the technology allows fast transmission and viewing of massive images in a seamless manner at multiple resolutions. For the first time the user can decompress a portion of interest from a larger compressed image. Depending on color depth and image content, MrSID achieves high compression ratios—from 25:1 for 8-bit gray-scale images to 100:1 for multispectral images—without perceptible loss of image quality. Originally developed for use in geographic information systems, the technology now has the potential for much wider applications. MrSID offers an efficient method for storing and retrieving photographic archives; it can store and retrieve satellite data for consumer games and educational CD-ROMs; and it is well suited for use in vehicle navigation systems. Moreover, MrSID promises to be useful in image compression and editing for desktop publishing and in nonlinear digital video software.



MrSID allows compression of large images without loss of critical information.

Quantum Cryptography

The secure distribution of the secret random-bit sequences known as “key” material is an essential precursor to their use for the encryption and decryption of confidential communications. Quantum cryptography is an emerging technology for secure key distribution with single-photon transmissions: Heisenberg’s uncertainty principle ensures that an adversary can neither successfully tap the key transmissions nor evade detection, as eavesdropping raises the key error rate above a threshold value.

Los Alamos physicists have developed experimental quantum cryptography systems based on the transmission of single-photon states to generate shared key material over multi-kilometer optical-fiber paths and over line-of-sight links such as those from a ground station to a low-Earth-orbit satellite. In both cases key material is built up by using the transmission of a single photon per bit of an initially secret random sequence. The nature of the quantum states ensures that an eavesdropper cannot identify the bit values in the key sequence. In our optical-fiber experiment we are using single-photon interference states to perform quantum key distribution over 24 kilometers of underground optical fiber, demonstrating that secure, real-time key generation over open optical-fiber communication links is possible. We have also constructed a quantum key distribution system for free-space, line-of-sight transmissions.

NUCLEAR AND ADVANCED MATERIALS

Cassini Heat Sources

Cassini, a joint U.S.-European orbiter and probe mission to Saturn and Titan, will be launched in October 1997, arriving at Saturn in 2004. Cassini’s four-year scientific mission at Saturn is dual: to complete a multispectral, orbital surveillance of Saturn and to investigate Titan, one of Saturn's moons. The Cassini data will be a major contribution to our scientific modeling of planetary atmospheres, which are important to human understanding of the evolution of Earth's own atmosphere. The Cassini Orbiter's multiple close flybys of Saturn's icy satellites also will provide insight into the nature of the many small planetlike bodies that may once have been prevalent in the outer solar system.

Cassini will be powered by three radioisotope thermoelectric generators (RTGs) made from plutonium dioxide incorporating the plutonium-238 isotope and fabricated at Los Alamos. Each RTG contains approximately 11 kilograms of plutonium dioxide. Each source radiates 4300 watts of heat energy to keep instruments warm and produces 290 watts of electricity to power the orbiter. The energy is produced from the radioactive decay of the plutonium-238, with an activity level of 134,000 curies.

Production of radioisotope heat sources for the Cassini mission began in January 1994. By September 1996, Los Alamos had delivered sufficient heat sources to power the spacecraft while maintaining personnel radiation exposures below the DOE administrative control level. Los Alamos also supported the test and qualification program for the approval process leading to the launch.

Structural Materials for Satellites

A large portion of the expense of sending a satellite into orbit is the cost of the initial launch. Spacecraft structures made from materials lighter than the commonly used aluminum alloys enable larger payloads to be sent into space for the same launcher cost. We designed and built a strong but lightweight composite satellite framework, using advanced polymer composites and a novel approach that reduces manufacturing time and cost and results in a structure with a high payload-to-weight ratio.

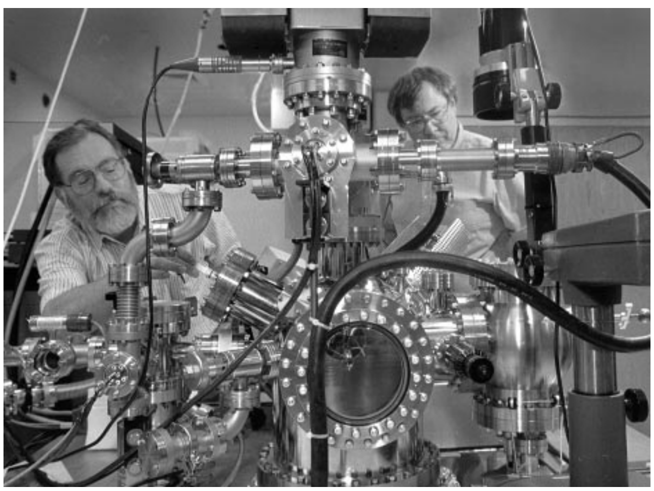
The manufacturing method minimizes the amount of tooling required and eliminates the need for expensive large production molds. The manufacturing method uses flat laminates of graphite epoxy composite that are nested and precut on a flat sheet, ready to be snapped out and assembled. This surprisingly simple manufacturing method is two-thirds faster and 60 percent less expensive than other methods for building strong, lightweight structures. The composite lightweight spacecraft structure for the FORTÉ satellite was developed with this method and built by the Laboratory in collaboration with Composite Optics Inc. It was one of five finalists selected by *Discover* magazine as the most outstanding advances in the aviation and aerospace category.

Hydrogen Membrane Filters

Laboratory researchers have developed thin-film technology to produce a fused sandwich of tantalum and palladium and created a membrane that is five times better than the best commercially available filter for purifying hydrogen. Compared with the standard dense palladium membrane, this new membrane will pass pure hydrogen at a faster rate and with a lower materials cost. In the new filter, the hydrogen molecule binds to the palladium surface, breaks into individual atoms, migrates through the metal layers, and recombines into a hydrogen molecule. The result is pure hydrogen that can be produced in high volume with little effort. In addition, the hybrid metal structure overcomes the cracking and oxidation common to previous membranes, operates well at high temperature and high pressure, and can be economically produced in large sheets or rolls. Applications for this new filter range from the pharmaceutical, biomedical, and power industries to advancing the development of hydrogen fuel cells, a technology that may replace gasoline-burning engines.

Permanent High-Density Memory Technology

Microscopic etching with a focused ion beam is a specialized capability available at Los Alamos for applications including customized targets and x-ray pin-hole camera apertures for the Inertial Confinement Fusion program. An emerging application involves making infrared band-pass filters for identifying certain frequencies of light in fiber-optic technology. Another application is the potential use of ion-beam etching to create high-density read-only memory (HD-ROM). This new information storage technology can provide an archival medium that cannot be destroyed by electromagnetic fields and is not sensitive to heat, cold, oxidation, decay, and other environmental factors. The HD-ROM technology could provide storage capabilities for bank transaction records, surveillance mapping, seismic records, government archives, genealogical libraries, and even audio and video cassette masters. In December 1995, NorSam Technologies Inc. of Santa Fe licensed the Los Alamos technology and announced plans to commercialize the HD-ROM technology and to build a manufacturing plant in northern New Mexico to produce the ion-beam writers that etch information onto HD-ROMs.



Los Alamos researchers adjust an ion-beam milling device used for the production of HD-ROMs.

Bioscience and Biotechnology

At Los Alamos the competencies that support our core mission enable work in the biological sciences. The study of complex problems in biology and health, by our staff, through Laboratory user facilities, and in collaboration with researchers worldwide will have major effects on drug design and therapy, on the engineering of efficient biological systems for bioremediation or bioprocessing of wastes, and on the precise determination of individual susceptibilities to risk agents in the environment.

Indirect Biological Effects of Ionizing Radiation

Alpha particles like those emitted from inhaled radon and radon progeny cause cancer. Increasing evidence indicates that particles can cause alterations in deoxyribonucleic acid (DNA) in the absence of direct “hits” to cell nuclei. We have found that a low dose of alpha particles may induce DNA damage through the generation of extracellular factors. When these factors are transferred to unexposed normal human cells, they cause DNA changes similar to those observed when the cells are directly irradiated with the same dose. A short-lived factor is generated in alpha-irradiated culture medium in the absence of cells, and a more persistent factor is produced by the cells themselves. We are trying to understand how these factors are transmitted in cell cultures in an effort to determine how these effects may be expressed in living organisms. These findings may have a profound effect on the current understanding of mechanisms of ionizing-radiation-induced carcinogenesis in the respiratory tract and on radiation risk assessment.

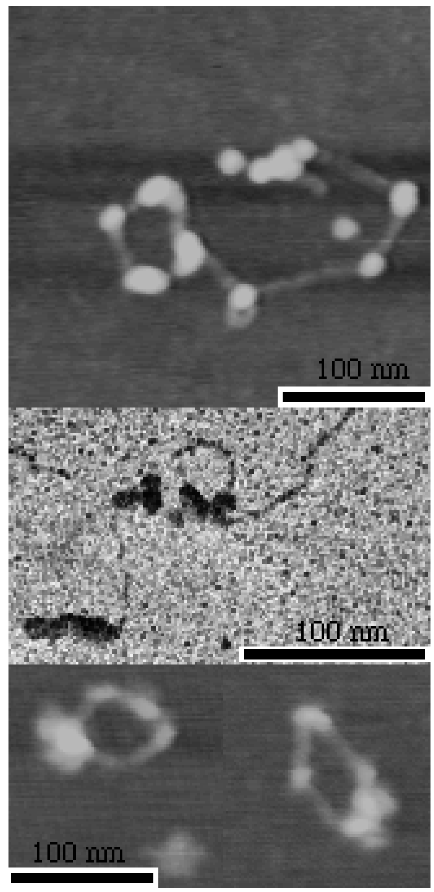
Microscopic Visualization of DNA-Protein Complexes

Many DNA repair proteins interact directly with damaged DNA. The resulting DNA-protein complexes may mediate changes in DNA structure necessary for efficient repair or precipitate the organization of a repair complex at the site of DNA damage. Studying the interaction between proteins and DNA is often difficult or impossible with traditional biochemical techniques. Nonetheless, understanding these processes is often critical to determining the biological role of DNA repair proteins. Using the Laboratory's state-of-the-art facilities for high-resolution microscopy, we are studying the interactions between DNA and the DNA-dependent protein kinase (DNA-PK).

Although genetic studies have demonstrated that DNA-PK is required for DNA double-strand break repair, the biological role of the protein has remained elusive. Our interdisciplinary effort has resulted in the first demonstration that this DNA-binding complex is likely to play a structural role in repair. The results suggest a model in which DNA-PK functions to tether broken DNA strands in proximity until they can be repaired. The experiments also indicate that high-resolution studies in collaboration with research at the University of California at Davis are likely to produce critical information for future experiments in determining the role of DNA-PK in the repair process.

Modeling HIV Dynamics in Vivo

Autoimmune deficiency syndrome (AIDS) develops slowly; the average time from human immunodeficiency virus (HIV) infection to the development of full-blown AIDS is about ten years. It was thought that much of this time was a period of clinical latency during which little activity occurred, with



Atomic force microscopy (top) and electron microscopy (middle) of the DNA binding component of DNA-PK associated with a linear DNA fragment illustrates the looping behavior. End-to-end tethering by the DNA-PK complex is shown here in atomic force micrographs of a linear DNA circularized by interactions between two DNA-bound DNA-PK complexes (top and bottom). These results suggest that inside the cell DNA-PK holds broken DNA strands together until repair can occur.

low but constant levels of virus and with infected cells in circulation. By perturbing the infection processes in a patient with potent antiviral drugs and then analyzing the data obtained with dynamical models, we established that HIV in fact replicates rapidly and is likewise cleared rapidly from the body. Our modeling established some surprising features of HIV infection: The average rate of HIV production is greater than 10 billion virus particles per day, but free virus particles are cleared with a half-life of six hours or less. Furthermore, productively infected T-cells have a life span shorter than 1.6 days.

As a result of our findings, the view of AIDS as a slowly developing disease that requires little attention for years after infection was replaced by a new paradigm that emphasizes rapid viral dynamics. Uncovering the rapid replication of HIV led to a new understanding of the rapid evolution of the virus and the seemingly inevitable emergence of drug-resistant forms. Treatment protocols featuring a single drug are being replaced by protocols composed of combinations of antiviral drugs, which have a greater antiviral effect and which increase the number of mutations needed for resistance. The early results of combination therapy, along with mathematical modeling, suggest that if viral replication can be completely suppressed for two to three years, the HIV infection may be eliminated from the body.

Space Sciences and Astrophysics

Los Alamos is a major participant in NASA's space research program. Some of our most significant recent discoveries of new phenomena in the high-latitude heliosphere were made by Los Alamos plasma instruments onboard the Ulysses spacecraft. The objective of the Ulysses experiment is to characterize the solar wind at high solar latitudes above the sun's poles. Los Alamos built the plasma analyzers that perform this characterization. Researchers observed some very interesting and unexpected solar wind velocities and developed a model that explains the observations.

Los Alamos is adapting the flight spares from Ulysses as plasma analyzers for the Advanced Composition Explorer mission, scheduled for launch in August 1997. This spacecraft will travel to the Earth-sun libration point, an orbit about one percent of the distance from Earth to the sun, where the gravitation and centrifugal forces match, so that the spacecraft orbits the sun with an angular velocity that matches Earth's. At this position, the spacecraft will function as an essentially constant-position, space-weather-monitoring point. This work is supported in part by UCDRD funds.

University Partnerships

University Students and Faculty at the Laboratory

At Los Alamos, we have more than 300 postdoctoral fellows at any given time (selected from a pool of over 2500 applicants) and about 700 undergraduate and 600 graduate students each summer (about 150 graduate students are doing thesis work at the Laboratory). In addition, we have contracts with over 200 university faculty members and affiliate agreements, which provide expenses for collaborative work, with more than 400 others. For many faculty members and staff members at the Laboratory, these interactions are a major source of intellectual stimulus and of ideas for future research.

University of California Directed Research and Development

At Los Alamos, UCDRD funds, derived from a portion of the University's management fee, enhance collaborations with the campuses and strengthen selected focus areas important to the Laboratory. The University supports three types of UCDRD-funded activities. The Collaborative University of California / Los Alamos Research Program funds small collaborative research projects between Laboratory and University researchers. The Visiting Scholar Program provides funds for Los Alamos staff to do research and related teaching at a University campus or for faculty to do research at Los Alamos. Research Partnership Initiatives foster the development of joint research capabilities that have the potential for external funding and significant research advances. Funding for the UCDRD activities, which began in FY 1994, has reached the planned level of $5 million per year. The number of projects supported by these funds grew to thirty-seven in FY 1996. The Visiting Scholar Program reached full-scale operation in FY 1996 with the selection of eleven participants. UCDRD supports a wide variety of projects, many of which are described elsewhere in this report.

Industry Partnerships

Working with industry continues to be an important part of the Laboratory's activities. Los Alamos scientists work with industrial partners to accomplish programmatic goals, to enhance the technology base available to the Laboratory, to understand "best business practices" in industry, to provide challenging new research opportunities for technical staff, and to enhance civilian research. Close industrial partnering arrangements are in place with various technical and programmatic areas of the Laboratory—the biosciences, chemistry, advanced manufacturing, environmental science, materials, and computational sciences.

In computational sciences, for instance, the Laboratory will acquire a state-of-the-art computer valued at $120 million as part of the Accelerated Strategic Computing Initiative. The initiative is designed to accelerate the development of high-performance computing to meet the needs of DOE in fulfilling stockpile stewardship responsibilities. The contract between Los Alamos National Laboratory and the Cray Research Division of Silicon Graphics, Inc., will push the limits of computational science and develop computing power to create virtual testing capabilities that will assist the Laboratory in meeting its mission.

Funding for the Laboratory's Technology Transfer Initiative has steadily declined to less than a third of the 1995 amount. This decline in funding has caused the Laboratory to manage its portfolio more closely to the Laboratory's core missions. After evaluation of the Laboratory's portfolio for both mission and programmatic impact, some partnerships were terminated in 1996. Partnerships are increasingly company-sponsored research or directly program related; almost a third of the Laboratory's partnerships fall into these categories, and the fraction is increasing.

Regional Economic Activities

In FY 1996 Los Alamos and DOE invested $900,000 in cooperative research and development projects with north-central New Mexico small businesses, to resolve technical problems or to boost technology maturation projects where commercialization might enhance the regional economy. The total funding available in FY 1997 for this program is $1.2 million. Both a technical review and a business review are used in the selection process. The primary goal for these funds, and the most important selection factor, is the potential for economic development in the region.

The Department of Commerce funded a demonstration project that will use the Internet for telemedicine applications in nine counties of rural northern New Mexico to serve hospitals, physicians, clinics, visiting nurses, and public health organizations. Working with Los Alamos, health clinics across New Mexico will establish patient-encounter records through a Los Alamos–developed, prototype telemedicine system that incorporates technology based on the concept of “virtual” patient records.

Various industrial partners have requested greater access and closer proximity to the Laboratory. The County of Los Alamos, DOE, the University of California, Los Alamos National Laboratory, and the local business community are working together to build a research park immediately adjacent to Laboratory property. Phase 1 calls for construction of a 50,000-square-foot building scheduled for completion in 1998.

University Industrial Partnership Activities

The University’s Office of Technology Transfer, the Laboratory, and regional stakeholders are collaborating on several projects. The goals of a proposed Technology Commercialization Pilot Program are to accelerate commercialization of Laboratory technologies in order to strengthen the regional and national economies and to simplify access to Laboratory facilities and staff by industrial partners. During FY 1997 we will establish the foundation for the program by realigning staff to form a Technology Commercialization Office. The office will nurture new start-up businesses based on Laboratory technologies and expand its small-business and entrepreneurial program initiatives.

Institutional Issues

"Each institution in the U.S. Government should be continually challenged to renew. This is not the natural talent of government."
Robert W. Galvin

Five years ago the report resulting from the massive Tiger Team inspection of 1991 emphasized the magnitude of the challenge before us. For the Laboratory to continue to do business, enormous changes were required both in the way we conducted our operations and in the way DOE interacted with us. The Laboratory embarked on a quality journey, learning from others who had survived similar challenges and studying the best of class across the nation. Our five-year goal was that the Laboratory would be not only the best scientific institution in the world but also the most productive. We launched our continuous quality improvement effort in 1992 and progressed well, reengineering many processes and restructuring Laboratory organization. However, our operations and business practices have not yet reached the level of quality necessary to fulfill our five-year goal.

One of the most important changes was to record operational data so that information, rather than negative anecdotes, would serve as the basis for DOE's evaluation of our performance. We accomplished this change through the performance management provisions in Appendix F of the University of California contract. The 1996 performance assessment by the University's Laboratory Administration Office showed impressive progress in nearly all operational and administrative areas. However, we still have much room for improvement and an ongoing need to practice continuous quality improvement.

Health and Safety

Although the Laboratory's long-term record for safety is impressive, in the last two years we have experienced a series of serious accidents, seemingly unrelated but suggesting weakness in the systems and structures that provide a safe working environment. On December 20, 1994, an employee of our contractor security force was killed during a training exercise when live ammunition was accidentally loaded into a weapon. On November 22, 1995, an employee lost control of a forklift and was severely injured when it rolled over. He subsequently recovered. On January 17, 1996, a contractor laborer received a severe shock when he jackhammered into a 13.5-kilovolt power line during an excavation project. He remains in a coma. On July 11, 1996, a graduate student working on energized, high-voltage equipment received a severe shock. He has recovered. As a result of these accidents, we have been subjected to intense scrutiny by DOE and the University.

In addition to making specific changes in response to the lessons learned from each of these accidents, we continued to make fundamental improvements to our underlying safety systems and practices. We developed, prioritized, and are tracking a set of actions that include the following:

- an integrated safety management program;
- a more effective safety communication program;
- a visible and meaningful safety performance consequences and rewards program; and
- clear, simple, and consistently implemented safety standards and work processes across the Laboratory.

We worked closely with the other weapons laboratories, DOE, and the Defense Nuclear Facilities Safety Board to develop the integrated safety management approach—a good, common-sense approach to safe operations. Notable features of the approach include input and participation from all levels of the workforce and strong emphasis on behavior-based safety management approaches. A University fact-finding group visited the Laboratory after the January 1996 accident and made recommendations consistent with our four priority areas. We take these recommendations very seriously and are implementing them. We emphasized our nuclear facilities first and have made good progress. In fact, our plutonium facility is now recognized by many as one of the best-run facilities in the DOE complex.

After the July 1996 incident, all work at the Laboratory was suspended for a Safety Day discussion among employees at all levels about workplace hazards and mitigating procedures. Because it was self-imposed and not mandated from outside the Laboratory, the Safety Day was successful, with many employees suggesting that it become a regular event. The necessary procedures, including communication plans, to create a more effective safety culture at the Laboratory are now in place. Ours is a logical and effective plan, which we must carry out with the courage of our convictions.

In October 1996 the DOE Office of Environment, Safety, and Health audited our operations, reiterated many of the same issues that the University's fact-finding group had raised, and acknowledged that we were addressing the problems in a suitable fashion. Nevertheless, DOE found many aspects of an effective safety culture lacking at the Laboratory. We continue to set a high priority on safety; for example, we made safety our primary tactical goal for the immediate future. As director, I am ultimately responsible for safety at the Laboratory, and I take that responsibility seriously.

Facility Management

Because our facilities are dispersed over forty-three square miles, it is difficult to manage them effectively in a centralized way. We are implementing a new approach for managing our facilities. We divided the Laboratory into logical facility management units and established facility managers that are located within the units. A Facility Management Council provides consistent implementation of Laboratory policy across the units. The distributed management system ensures that work performed is closely aligned with needs and priorities of the scientific and technical operating organizations within the facilities. We are also dispersing support personnel such as safety experts into the field to work directly with the facility managers.

We are trying hard to improve operating efficiencies. The process by which all facilities' work is requested and completed, known as work control, is being reengineered and automated to increase efficiency and ensure safety. In addition, we implemented a zone maintenance system with dedicated teams of craft workers assigned to contiguous facility management units. This system will reduce travel time, allow more effective work scheduling, and result in a team familiar with buildings within their zone.

The Laboratory has also dramatically improved its safeguards and security performance. In the 1993 DOE annual survey, six of the eight security topical areas were rated marginal. In the 1994 survey, six of the eight were rated satisfactory. In the 1995 program review, both topical areas rated less than satisfactory from the 1994 evaluation were upgraded to a rating of satisfactory. DOE has agreed to delay the 1996 survey based on a satisfactory review of the Laboratory's model security self-assessment program until the spring of 1997.

Site-Wide Environmental Impact Statement

In August 1994 the DOE announced its intention to prepare a new site-wide environmental impact statement (EIS) for Los Alamos, in order to provide a comprehensive and cumulative look at the environmental impacts of both ongoing Laboratory activities and projected activities and operations foreseen within the next five to ten years. This EIS will enable the Laboratory to become a better steward of the environment and will be useful as a planning tool. The Laboratory is playing a critical role in the support of the EIS preparation in various ways, for example, by providing data about the Laboratory and reviewing drafts as they are generated.

During the complex process of EIS preparation—release of a draft is expected in February 1997—the Laboratory has prepared reviews of several projects that receive complete coverage in the EIS, developed site and facility descriptions, and coordinated the compilation of data for the process. The Laboratory project office has prepared a baseline information document that will be published and made available to the public, in effect as a supplement to the EIS. Because it will provide information that might be available only in summary form in the EIS itself, it will serve as a valuable source of comprehensive information.

Environment

The Tiger Team experience of 1991 and the increasing external regulation of Laboratory operations taught us to take a new approach to management of the overall site. Spread across a large area and built over fifty years, new Laboratory facilities had been treated as if they were independent and were not adequately integrated into the infrastructure. The result was a myriad of outfalls and emission sources. Further, few of these were adequately monitored or permitted to meet the requirements of the emerging world of external regulation. We are working diligently and making significant progress toward correcting the situation.

One Laboratory goal is to reduce the number of National Pollutant Discharge Elimination System (NPDES) outfalls through the reduction of wastewater sources, effluent reuse, land application, and other conservation techniques. Over the past several years, the Laboratory reduced the number of outfalls monitored under its NPDES permit from 141 to eighty-eight. Compliance with effluent limitations required under the NPDES permit is now 98 to 99 percent.

The Laboratory currently operates its wastewater treatment facilities under an administrative order issued by the Environmental Protection Agency (EPA). All identified deficiencies are scheduled to be remedied by March 31, 1997. We recently completed the new High-Explosives Wastewater Treatment Plant in accordance with terms of the EPA order.

During the past three years, the Laboratory has undertaken an aggressive program to reduce the number of stacks that can emit radionuclides. To comply with EPA or DOE regulations, we are also reducing the number of remaining stacks that require sampling. We have reduced the numbers by terminating or consolidating operations, consolidating stack effluents, decontaminating and decommissioning facilities, and developing less conservative but technically sound and EPA-approved approaches for determining a stack's emission potential.

The Laboratory is now in full compliance with 40 CFR 61, Subpart H, the Clean Air Act radionuclide National Emissions Standards for Hazardous Air Pollutants Standard for DOE facilities. This completes a six-year effort to upgrade stack sampling and negotiations with EPA Region 6 and plaintiffs in a citizen lawsuit against the Laboratory.

The effectiveness of Laboratory environmental compliance programs is exemplified by a decrease in the number of violations and fines under the New Mexico Environment Department (NMED) Resource Conservation and Recovery Act, with no violations noted for other media. NMED commended DOE and the Laboratory for the improvements in hazardous waste management and for our efforts to go beyond compliance in order to improve our relationship with NMED and to achieve excellence in environmental stewardship.

Workforce Productivity Project

Slightly over a year ago, we took one of the most wrenching steps in our drive to position the Laboratory for the future. We reduced the size of the support staff by nearly 1000, or about 10 percent of the total workforce, in an effort to reduce support costs and make the Laboratory more competitive. The reduction was accomplished in part through reductions in our contractor workforce, in part through a voluntary separation plan, and most painfully, through the involuntary separation of 200 University employees. This action reduced the overhead rate of our technical programs by about $60 million. As a result, the $60 million remained in the scientific and engineering programs, and the Laboratory provided more science and technology to its customers.

In addition, these measures allowed the Laboratory to meet DOE requirements to reduce costs. In December 1994 Secretary of Energy Hazel O'Leary set targets for substantial reductions in the costs of DOE as part of the efforts to scale back the costs of the federal government. Each laboratory was asked to take actions to help meet those targets. The secretary's instructions were part of the motivation that led Los Alamos to initiate cost reductions early rather than late. Many other DOE sites and laboratories are now faced with taking actions similar to those taken by Los Alamos last year.

Our overhead rates, while not yet to the level of the 1980s rates, showed significant improvements for FY 1996, which we expect to maintain in FY 1997.

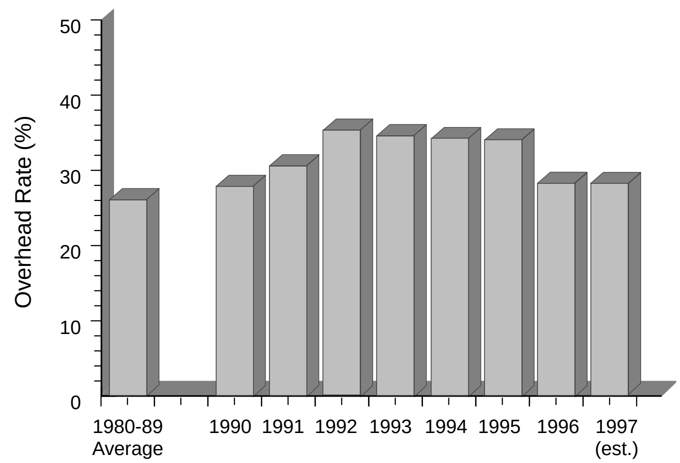
Diversity

Because the Laboratory is the dominant employer in northern New Mexico, the personnel actions taken last year had the potential to severely affect the communities that depend on the Laboratory for their support. The actions we had to take shook the confidence that many had in the Laboratory as an employer of great stability. Although we believe that the personnel actions taken were done in a fair and equitable manner, the reduction in overhead required reductions in skills groups that were heavily populated by women and Hispanics and this led to complaints of discrimination to the Office of Federal Contract Compliance Programs. In its preliminary findings, the office has found cause for concern; we are discussing its analysis of the data with the office, as we draw a different conclusion from the same data. The Laboratory remains committed to furthering its workforce diversity and includes initiatives in technology transfer, subcontracting, science education outreach, and community involvement and outreach in its diversity activities.

The Laboratory initiated an institutional recruitment program in which the Diversity Office created last year supports efforts in human resources. We proposed to recruit at thirteen colleges and universities during the fall of 1997. In order to improve employee communication on diversity issues, a number of advisory groups were established, including an external advisory council, the Laboratory Diversity Council, and Women's, Hispanic, Asian American, Native American, and African American Diversity Working Groups. An internal team to evaluate the Laboratory's activities in mentoring, succession planning, and career development recommends that we enhance opportunities for all employees to compete effectively for positions of increasing responsibility. We will implement this recommendation next year.

Community Concerns

One way we demonstrate concern for northern New Mexico communities is through a change in our approach to contracting. In the past we required our contractors to do work for the Laboratory and judged them solely on the basis of that work; we are now broadening our requirements to include substantial investment in the communities.



The Laboratory's overhead rate is shown as a percent of the operating budget. The reductions are a result of our workforce productivity project.

Over the past year we explored several new channels for engaging the residents of northern New Mexico in issues associated with regional economic development and diversification. The resulting dialogue spurred the University and the Laboratory to develop several new initiatives. Creating the University of California–Northern New Mexico office was a positive step. We also developed a new approach to purchasing practices, which has already begun to yield positive benefits for the region.

Last winter a working group of regional community, University, and Laboratory leaders was formed in order to develop strategies and actions for strengthening the regional economy and reducing the dependence on federal expenditures. Because the Laboratory spends over half its operating budget on procurement, purchasing practices were identified as a key opportunity to leverage the federal investment in the Laboratory to the greater benefit of the region.

As a result of the working group's input, we developed an institutional strategy and action plan for contracting, outsourcing, and corporate partnering that identified three objectives: increased productivity, increased job opportunities for the workforce, and increased regional economic development opportunities. These objectives are used to revise the terms of major contracts that are up for bid. In particular, prospective contractors are now asked to explain how they would promote economic diversification by bringing non-Laboratory-related business to the region or by making investments in the region. This strategy is already bearing fruit. In October 1996 we finalized an architectural and engineering contract with Fluor Daniel Inc., associated with several major construction projects at the Laboratory. Fluor Daniel indicated that it will locate a new corporate training facility in Española, which could yield 150 to 200 new jobs for the region.

Other actions include (1) the formation of a Northern New Mexico Procurement Advisory Council with members from the Española, Santa Fe, and Los Alamos Chambers of Commerce and the Eight Northern Pueblos; (2) retaining a very successful, minority-owned small business to cultivate the regional supplier base through mentoring, formation of supplier alliances, and relocation of best-in-class suppliers to the region; and (3) adding incentives and requirements for contractors to move or set up local offices to increase regional revenues from state gross receipts taxes and to build up the regional infrastructure.

The measures taken by the Laboratory help to better position us with respect to customers for the research and development conducted at the Laboratory. Increased business will help the Laboratory remain in the forefront of science and creates the potential for hiring additional employees in the future.

Educational Outreach

Our future success depends on the availability of a well-educated workforce; we realize that the place to start developing that workforce is in our schools, particularly schools in New Mexico. For many years the Laboratory has maintained an active education program, funded by DOE, for kindergarten through twelfth grade. This program continues despite shrinking national budgets. We also realize that the nature of our work means that young people often need further education so that they can compete effectively for positions at the Laboratory. We are taking steps to improve opportunities for outstanding local young people who wish to pursue training at local community colleges.

The Laboratory's program in primary and secondary education consists of thirty-four different projects that reach 2387 students, teachers, and administrators at all levels. Every project is directly connected with the unique resources of the Laboratory and is based on our technical programs and core competencies. Los Alamos scientists and technicians routinely discuss scientific content and demonstrate current research. These direct contacts with active science projects are exciting for the participants and help them make the connection between the science and math studied and the current application in research.

Many projects involve collaboration with universities; most involve the application of technologies such as computer networking and the Internet; some help schools establish their own networks and connection to the Internet. All of our projects emphasize the providing of opportunities to students from underrepresented groups. Some projects, such as the Underrepresented Minorities and Females Project and the Historically Black Colleges and Universities Project, specifically target such groups. Most projects are nonselective; that is, every applicant is accepted.

In order to create more opportunities for post-high-school education, the Laboratory is establishing a philanthropic entity to foster and manage gift and grant support for local students who are interested in continuing their education beyond high school. The Los Alamos National Laboratory Foundation will assist in the promotion and financial support of the research, education, and public service activities of the Laboratory. The foundation is being organized as a New Mexico nonprofit corporation and will function as a charitable organization under state and federal income tax laws. To fulfill one of its principal goals, the foundation will support college scholarships for local young people.

Outreach activities with local community colleges include summer internships that enable students to come to the Laboratory for work experience, as well as programs in environmental technologies, manufacturing sciences, computer sciences, and other areas. Experience with these programs is intended to encourage the best of our local students to consider careers at the Laboratory.

The Laboratory is working closely with Northern New Mexico Community College, which has identified the development of a telecommunications infrastructure as one of its priorities. The college is the focal point for the development of a “telecommunity,” which includes five of the local pueblos, and a regional network for Rio Arriba County. We are sharing our technical competence in this area to leverage the college’s productivity. Our assistance has included helping to set up their Internet access; conducting a number of Internet training workshops for staff, city, and county government personnel, pueblo teachers and administrators, and small-business people; and developing a proposal and long-range plan with the local telecommunications provider for a wide-area communication network in the county. These activities will clearly enhance the economic vitality and quality of life for the region.

Awards and Honors

External Awards and Honors

In the past year external professional organizations and institutions recognized many Laboratory employees in various ways for their achievements—by electing them to honorary positions, bestowing awards, and granting professorial appointments or honorary degrees. In addition, Los Alamos was well represented on advisory boards and the editorial boards of major scientific and engineering journals. Laboratory personnel were active in organizing committees of major national and international conferences and symposia, and they appeared as invited speakers at seminars and conferences. The complete list of employee achievements during 1996 is too long to be included here. The partial list that follows demonstrates the range of accomplishment and professional involvement of Los Alamos employees.

Elections to the National Academy of Sciences and the National Academy of Engineering

Two Laboratory physicists, George Zweig and Zachary Fisk, were elected to the National Academy of Sciences. Zweig's research has covered such disparate fields as high-energy physics, auditory physiology, applied mathematics, and digital signal processing; he is best known for his independent discovery of quarks. Fisk, a former Laboratory employee who maintains professional ties with the Materials Science and Technology Division, is best known for his discovery and synthesis of new magnetic and superconducting materials and for pioneering research on their properties.

Warren "Pete" Miller was elected to the National Academy of Engineering. Miller was cited for his contributions to the theory of radiation transport and nuclear engineering education.

R&D 100 Awards

This year the Laboratory won two R&D 100 Awards in the international awards program sponsored by *R&D Magazine*. The program honors the top 100 technical advances of the previous year. Technologies are nominated in an open competition and selected according to technical criteria that identify the most important, unique, and useful entries. Gary Selwyn received the R&D 100 Award for PLASMAX, a plasma mechanical cleaner for silicon wafers. David Cremers, Monty Ferris, Mathew Davies, and A. William Laughlin received the R&D 100 Award for TRACER, a transportable remote analyzer for characterization and environmental remediation. The two wins bring the Laboratory's total number of awards to forty-six over the past eight years.

Achievement Awards

Laboratory personnel received numerous awards and honors from a variety of government and professional organizations. The following list is representative: Diane Albert, the 1996 Governor's Award for Outstanding New Mexico Women; Dharam Ahluwalia and C. Burgard, the Gravity Research Foundation Award for the best essay on general relativity and gravitation, “Gravitationally Induced Neutrino-Oscillation Phases”; David L. Bish, the Marion L. and Chrystie M. Jackson Mid-Career Clay Scientist Award of the Clay Minerals Society; Lawrence Bruckner, the Harlan J. Anderson Award from the American Society of Testing Materials; H. W. Egdorf, a USENIX Lifetime Achievement Award; Thomas A. Garcia, the 1996 El Camino Real Award from the Hispano Chamber of Commerce del Norte for promoting economic development; Denise George, the 1996 Grace Barker Wilson Award from the New Mexico Division of the American Association of University Women; Timothy George, the James F. Lincoln Arc Welding Foundation Bronze Award; and Gary Glatzmaier, the Sidney Fernbach Award from the Electrical and Electronics Engineers Computer Society for his modeling of the Earth’s geodynamo. Glatzmaier was also one of five finalists in the 1996 Computerworld-Smithsonian Award.

Siegfried S. Hecker was awarded the Navy League New York Council’s Roosevelts Gold Medal for Science Award. Hecker and Victor Reis were recognized by *Aviation Week & Space Technology* for their leadership in crafting a science-based nuclear stockpile stewardship program designed to ensure that weapons remain safe and function predictably in the absence of full-scale testing. The American Business Women’s Association named Janet L. Martinez Woman of the Year. The Central States Communication Association recognized Ann M. Mayer-Guell for presenting the top paper for the Organizational and Applied Communication Division. The National Aeronautics and Space Administration named Don Pettit and John L. Phillips to the 1996 NASA Astronaut Class; both will train as mission specialists. Also receiving awards were Richard Keller, the Lester W. Strock Award from the Society of Applied Spectroscopy; John Nolan, the Presidential Award for Excellence from the International Society for Analytical Cytology; Marie Roybal, the Quality Hero Award from the Quality New Mexico organization; and William H. Woodruff, the Elisabeth Roberts Cole Award from the Biophysical Society and the Bomem-Michelson Award from the Coblentz Society.

Academic Awards and Honors

During the past year Fulbright Scholarships were awarded to Scott Baldridge, who will study at the Mineralogical Petrological Museum at the University of Oslo in Norway, and Ronnie Mainieri, who will study at the Niels Bohr Institute in Denmark. The Council for International Exchange of Scholars also named Charles Doering a Fulbright Scholar. Paul Kotula was named a Presidential Scholar by the Microscopy Society of America.

Election of Fellows

The following Laboratory personnel were elected to the rank of fellow by their professional organizations: Irving Bigio, American Society for Laser Medicine and Surgery; Shi-Yi Chen, James Cohen, Lee Collins, Martin Cooper, George Csanak, Peter Lomdahl, and Susan J. Seestrom, American Physical Society; George Kyrala, International Society for Optical Engineering; Bruce Matthews, American Nuclear Society; K. K. S. Pillay, the American Institute of Chemists and the American Nuclear Society; and Patrick Rodriguez, National Consortium for Graduate Degrees for Minorities in Engineering and Science.

Department of Energy Awards and Awards from Other Contractors

Los Alamos received an Accomplishment Award in the second annual DOE Quality Awards Program. The criteria for the award are based on leadership, information and analysis, strategic planning, human resource management and development, process management, business results, and customer focus and satisfaction. Los Alamos also won a DOE Quality Champion Award this year.

Individuals receiving awards include the following: Irving Bigio and Bruce Wienke, Federal Laboratory Consortium Awards for Excellence in Technology Transfer; Mark Chadwick, Distinguished Achievement Award from Lawrence Livermore National Laboratory; Richard Henderson, DOE Award of Excellence for Significant Contributions to the Nuclear Weapons Program; Joseph Jackson and Stephen Nielson, Westinghouse-Savannah River Site Most Valuable Person Awards for work in modeling tritium facility operations; Lawrence Kreyer, DOE Nuclear Weapons Program Award of Excellence; Bruce Matthews, Dana Christensen, David Post, Don Knuth, Rabi Singh, Dan Rose, D. Glenn, and Rudy J. Valdez, DOE Quality Award–Gold, for a continuous quality improvement approach to plutonium operations at Technical Area 55; David O'Brien, DOE Award of Excellence; and Dale Talbott, DOE Award of Excellence and DoD Joint Meritorious Unit Award.

Appointments and Elections

Among the many Laboratory personnel appointed in 1996 to advisory posts or elected to offices of professional organizations are the following: Michael Altherr, editor for Human Chromosome 4 by the Human Genome Organization; Cynthia Blackwell, chair-elect for the Congress Program, 1997 National Safety Council, Research and Development Section; Norman Doggett, 1997 co-chairman and 1998 chairman of the Human Gene Mapping Committee of the Human Genome Organization; Betty Harris, president of the New Mexico Federation of Business and Professional Women; Jody Heiken, president of the Society for Technical Communication; K. K. S. Pillay, chairman-elect of the Isotopes and Radiation Division of the American Nuclear Society and vice-chair of the American Nuclear Society National Honors and Awards Committee; and Cetin Unal, treasurer of the Thermal Hydraulics Division of the American Nuclear Society.

Patents

In 1996 Laboratory employees filed ninety patent applications and received thirty-four patents.

Internal Awards and Honors

Los Alamos conducts an active internal awards program, which rewards Laboratory employees for their achievements. The program recognizes both the scientific accomplishments of the technical staff and the invaluable contributions of support personnel.

Laboratory Fellows

In 1996 six technical staff members were appointed Los Alamos National Laboratory Fellows in recognition of their outstanding achievements in a variety of scientific disciplines. The newly appointed are Christopher Morris, John Pedicini, Jen-Chieh Peng, Darryl Smith, Johndale Solem, and Wojciech Zurek. The Laboratory Fellows represent a select group; the number of those who are also regular employees is limited to about 2 percent of the Laboratory's technical staff members. Since the inception of the fellows program in 1980, only 123 technical staff members have achieved the rank of fellow.

Each year, the Laboratory Fellows recognize outstanding research in science or engineering by Laboratory scientists through the Fellows Prizes. In 1996 Michael Nastasi, Joe D. Thompson, and Stuart Trugman were honored individually for their research and scientific contributions during the past ten years.

Distinguished Performance Awards

The Laboratory recognizes its employees with Distinguished Performance Awards for job performance above and beyond that which is normally expected. The 1996 awards were presented to sixteen individuals, six small teams (up to six individuals), and six large teams (more than six individuals). Some of the teams were the Comprehensive Test Ban Treaty Negotiations Technical Support Team, the Human Genome Project Team, the Pit Surveillance Project Team, the Transuranic Waste Characterization Project Team, the Laser Beam Deflection by Plasma Flow Experiment Team, and the Laboratory Directed Research and Development Team.

Inventor Awards

The Laboratory recognizes those employees who receive patents during the year and selects the most notable patents for the Laboratory's Distinguished Patent Award. In 1996, seventy-four employees received patents; the Distinguished Patent Award went to James Jett, Richard Keller, John Martin, Babetta Marrone, Mark Hammond, Richard Posner, and Daniel Simpson for their method for rapid base sequencing in DNA and RNA with two-base labeling.

Awards for Excellence in Industrial Partnerships

This year 153 Laboratory researchers and industrial specialists were recognized with awards to nine individuals and sixteen teams for outstanding contributions and accomplishments in sharing Laboratory-developed technology and technical expertise with U.S. businesses and industries. The awards emphasize partnerships that foster the Laboratory's central mission of reducing the nuclear danger and support core competencies that enable the Laboratory to meet defense, civilian, and industrial needs. Contributions that foster regional economic development are also recognized.

Los Alamos Awards

In 1996 the Laboratory started a two-year pilot program of monetary awards to recognize employees for exceptional contributions or noteworthy achievements that surpass job expectations or goals. Thus far, 978 people have received awards.

BUDGET AND STAFFING

Funds to operate the Laboratory come from DOE, DoD, various federal agencies, and other organizations in the private and public sectors. These funds support a broad range of research and development activities that reflect national priorities. As these priorities change, the Laboratory and its sponsors adjust the budgetary allocations for specific programs.

The budget for nuclear weapons research, development, and testing has increased substantially after some years of decline, reflecting in part substantial investments in the Los Alamos Neutron Scattering Center and in the accelerator production of tritium. DOE provided, directly or indirectly, 90 percent of our operating funds in FY 1996; DoD provided 5 percent, with other organizations and agencies providing the balance.

Resource Estimates—FY 1994–FY 1996

	Funding ($M)			Personnel (FTE)		
	FY 1995	FY 1996	FY 1997	FY 1995	FY 1996	FY 1997
DOE Defense Activities	523	586	686	3680	4140	4430
Environmental Restoration, Waste Management, and Corrective Actions*	210	148	141	920	700	670
DoD and Intelligence	85	62	63	510	360	350
Energy Research and Technology	263	212	200	1990	1510	1370
Total	1081	1008	1090	7100	6710**	6820

**Much of the funding for environmental restoration and waste management activities covers contract labor and goods and services.*

***There were 6790 FTEs on board as of October 1, 1996; there was an average of 6710 FTEs through September 1996.*

LALP-96-152
December 1996

Los Alamos
NATIONAL LABORATORY
Los Alamos, New Mexico 87545